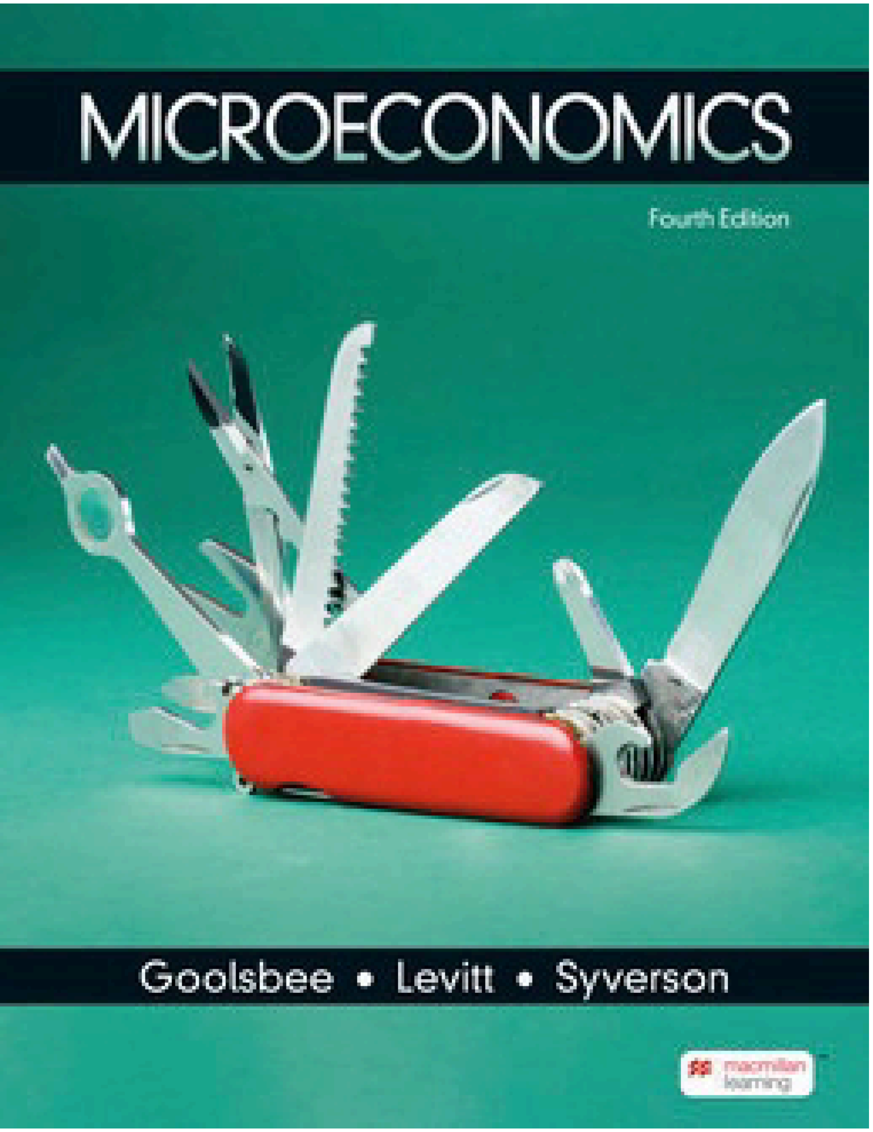
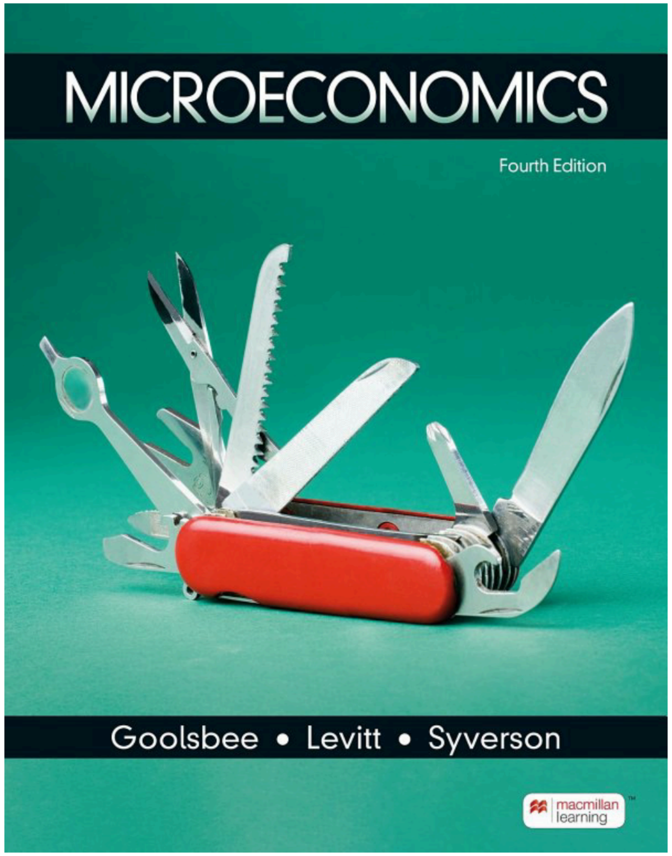


MICROECONOMICS

Fourth Edition

Goolsbee • Levitt • Syverson

macmillan learning



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Microeconomics

FOURTH EDITION

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From Austan

To Aden, Addison, and Emmett

From Steve

To the next generation of economists, whose wisdom will shape the future

From Chad

To my wife Genaya and my children Claire, Adam, Victoria, and Gabrielle

From all

And to the University of Chicago, where people don't just study economics, they live it, breathe it, eat it, and sleep it. The world of economics would never be the same without you, and neither would we.

Achieve for *Microeconomics*

Engaging Every Student. Supporting Every Instructor. Proven Success. Continued Enhancement.

Macmillan Learning's Achieve for Microeconomics sets the standard for integrating **activities, assessments,** and **analytics** into your teaching. It brings together all of the features that instructors and students need—an e-book with interactive graphing, LearningCurve adaptive quizzing, and other instructional and application activities, assessments, and extensive instructor resources—in a powerful platform that offers:

- Deep platform integration with all LMS providers.
- Powerful assessment and adaptive quizzing.
- A fully integrated iClicker classroom response system.
- Exciting, enhanced, interactive graphing tools.

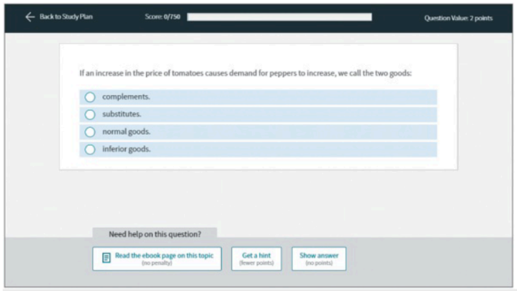
Our resources were **co-designed with instructors and students**, using a foundation of **learning research** and rigorous testing. The result is pedagogically superior content, organization, and functionality. Achieve's pre-built assignments engage students both *inside* and *outside* of class. And Achieve is effective for students of *all levels* of motivation and preparedness, whether they are high achievers or need extra support.

Macmillan Learning offers **deep platform integration** of Achieve with all LMS providers, including Blackboard, Brightspace, Canvas, and Moodle. With integration, students can access course content and their grades through one sign-in. And you can pair Achieve with course tools from your LMS, such as discussion boards and chat and Gradebook functionality. LMS integration is also available with Inclusive Access. For more information, visit MacmillanLearning.com/College/US/Solutions/LMS-Integration or talk to your local sales representative.

Achieve was built with **accessibility** in mind. Macmillan Learning strives to create products that are usable by all learners and meet universally applied accessibility standards. In addition to addressing product compatibility with assistive technologies such as screen reader software, alternative keyboard devices, and voice recognition products, we are working to ensure that the content and platforms we provide are fully accessible. For more information visit https://www.macmillanlearning.com/college/us/our-story/accessibility.

LearningCurve Adaptive Quizzing

With a game-like interface, this popular and effective quizzing engine offers students a low-stakes way to brush up on concepts and help identify knowledge gaps. Questions are linked to relevant e-book sections, providing both the incentive to read and a framework for an efficient reading experience.


Back to Study Plan
Score: 0/750
Question Value: 2 points
Need help on this question?
Read the ebook page on this topic (no penalty)
Get a hint (fewer points)
Show answer (no points)

If an increase in the price of tomatoes causes demand for peppers to increase, we call the two goods:

○ complements.
○ substitutes.
○ normal goods.
○ inferior goods.

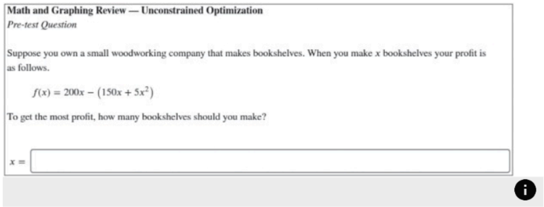
Enhanced E-Book

The Achieve e-book offers highlighting, bookmarking, and note-taking. Students can download the e-book to read offline or to have it read aloud to them. Achieve allows instructors to assign chapter sections as homework.

ACTIVITIES

Math and Graphing Review Tutorials

The math and graphing video tutorials are a helpful tool for students to review basic mathematical concepts and how to apply them. Additionally, there are tutorials that cover more advanced math and graphing concepts specific to intermediate microeconomics. These tutorials contain video explanations, as well as multiple-choice assessments to help students apply the concepts learned in the videos.



Math and Graphing Review — Unconstrained Optimization

Pre-test Question

Suppose you own a small woodworking company that makes bookshelves. When you make x bookshelves your profit is as follows.

$$f(x) = 200x - (150x + 5x^2)$$

To get the most profit, how many bookshelves should you make?

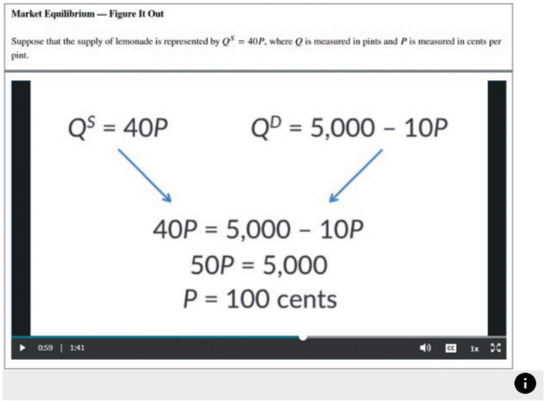
$x =$

Freakonomics Activity Guides

These in-class activities are based on the unique examples in the text's signature *Freakonomics* feature. Authored by Andrea Valenzuela, this activity uses the *Freakonomics* feature as a way to practically apply the text's concepts and to bring the conversation into the classroom. These PowerPoint decks include multiple-choice, open-response, and graph-based questions to engage students as they apply these interesting examples.

Figure It Out

These problems expand on the text's popular feature of the same name and guide students through the process of applying economic analysis and using math to solve select Figure It Out problems found in the text. These detailed, worked-out problems will better prepare students to complete the end-of-chapter exercises and questions found on quizzes and exams. These tutorials include thorough feedback and video explanations, providing students with interactive assistance for each step of the problem.



Market Equilibrium — Figure It Out

Suppose that the supply of lemonade is represented by $Q^S = 40P$, where Q is measured in pints and P is measured in cents per pint.

$$Q^S = 40P \qquad Q^D = 5{,}000 - 10P$$

$$40P = 5{,}000 - 10P$$

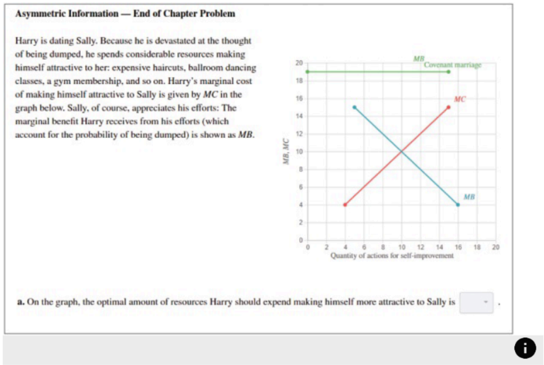
$$50P = 5{,}000$$

$$P = 100 \text{ cents}$$

ASSESSMENTS

End-of-Chapter Questions

Developed by economists active in the classroom, these multistep problems are paired with rich feedback for incorrect and correct responses that guide students through the process of problem solving. These questions also feature our user-friendly graphing tool, designed so students focus entirely on economics and not on how to use the application.



Asymmetric Information — End of Chapter Problem

Harry is dating Sally. Because he is devastated at the thought of being dumped, he spends considerable resources making himself attractive to her: expensive haircuts, ballroom dancing classes, a gym membership, and so on. Harry's marginal cost of making himself attractive to Sally is given by *MC* in the graph below. Sally, of course, appreciates his efforts: The marginal benefit Harry receives from his efforts (which account for the probability of being dumped) is shown as *MB*.

a. On the graph, the optimal amount of resources Harry should expend making himself more attractive to Sally is ☐ .

Homework

Curated homework problems feature randomly sampled variables and our user-friendly graphing tool. These problems are multistep with a variety of answer inputs—each with detailed and targeted feedback specific to that answer.

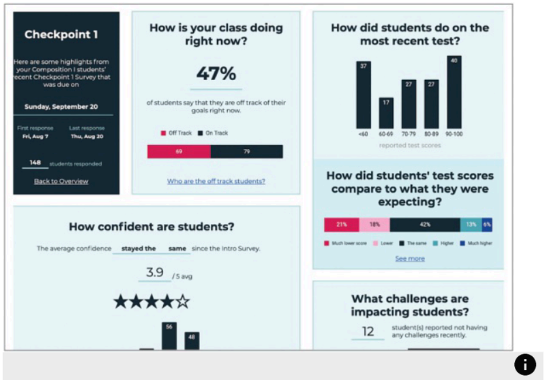
Practice Quizzes

Designed to be used as a study tool, these quizzes feature multiple-choice questions and allow for multiple attempts as students familiarize themselves with content.

ANALYTICS

Learning Objectives, Reports, and Insights

Every asset you can assign in Achieve is tagged to specific Learning Objectives. Reporting within Achieve helps students see how they are performing against objectives, and it helps instructors determine if any student, group of students, or the class as a whole needs extra help in specific areas. This enables more efficient and effective instructor interventions.



Checkpoint 1

Here are some highlights from your Composition I students' recent Checkpoint 1 Survey that was due on

Sunday, September 20

First response Fri, Aug 7

Last response Thu, Aug 20

148 students responded

Back to Overview

How is your class doing right now?

47% of students say that they are off track of their goals right now.

Who are the off track students?

How did students do on the most recent test?

How did students' test scores compare to what they were expecting?

See more

How confident are students?

The average confidence stayed the same since the Intro Survey.

3.9 /5 avg

What challenges are impacting students?

12 student(s) reported not having any challenges recently.

Achieve provides reports on student activities, assignments, and assessments at the course level, unit level, subunit level, and individual student level, so instructors can identify trouble spots and adjust their efforts accordingly. Within Reports, the Insights section offers snapshots with high-level data on student performance and behavior, to answer such questions as:

- What are the top Learning Objectives to review in this unit?
- What are the top assignments to review?
- What's the range of performance on a particular assignment?
- How many students aren't logging in?

Powerful Support for Instructors

Test Bank

This comprehensive Test Bank contains multiple-choice questions, numerical problems, and short-answer questions to help instructors assess students' comprehension, interpretation, and ability to synthesize. Additionally, there is a separate bank of calculus questions to accompany each appendix chapter.

Lecture Slides

These brief, interactive, and visually interesting slides are designed to hold students' attention in class with graphics and animations demonstrating key concepts and real-world examples.

Clicker Slides

These slides contain questions to incorporate active learning in the classroom. Students can participate by using the iClicker app on their smartphone or laptop.

iClicker Integration

With Achieve's seamless integration with iClicker, you can help any student participate—in the classroom or virtually. iClicker's attendance feature gets students in class, then instructors can choose from flexible polling and quizzing options to engage, check understanding, and get feedback from students in real time. iClicker also allows students to participate using laptops, mobile devices, or iClicker remotes—whichever each student prefers. Additionally, we offer Instructor Activity Guides and book-specific iClicker question slides within Achieve to make the most out of your class time. It's no surprise that over a decade after being founded by educators, iClicker still leads the market. And thousands of instructors continue to give every student a voice with our simple, award-winning student engagement solutions.

Instructor's Resource Manual

The Instructor's Resource Manual offers instructors teaching materials and tips to enhance the classroom experience, along with detailed lecture outlines, and additional Figure It Outs.

Gradebook

Assignment scores are collected into a comprehensive Gradebook providing instructors reporting on individuals and overall course performance.

Customer Support

Our Achieve Client Success Specialist Team—dedicated platform experts—provides collaboration, software expertise, and consulting to tailor each course to fit your instructional goals and student needs. Start with a demo at a time that works for you to learn more about how to set up your customized course. Talk to your sales representative or visit https://www.macmillanlearning.com/college/us/contact-us/training-and-demos for more information.

Pricing and bundling options are available at the Macmillan student store.

The Story of *Microeconomics*

The overwhelming majority of instructors and students use Achieve online courseware for *Microeconomics*. The new edition offers significant improvements to Achieve, including:

- **New homework assignments available in Achieve.** Reimagined assessment offers targeted feedback for use in class and as homework assignments. Designed so that students learn by doing the economics, these problems contain multiple question types, including our innovative and intuitive graphing tool that assesses students' understanding of economics and not their use of graphing software. Each chapter offers a new set of assignable, multi-step problems that complement online, auto-graded versions of the end-of-chapter problems.

The fourth edition of the text has new coverage and updates throughout. In particular:

Chapter 1

- *Application: Rideshare Driving the Microeconomics Way* has been updated with references to Uber and Lyft drivers' costs, potential investment in electric vehicles, and mention of option to drive for UberEats instead of passenger service.

Chapter 2

- A new chapter opening example is about the market for office space in the wake of the Covid-19 pandemic.
- *Application: Supply Shifts and the Classic Video Game Crash* includes updated figures on video game sales.
- The Elasticities and Time Horizons section includes new references to remote work options.
- The Income Elasticity of Demand section has been reorganized to present normal goods first, followed by luxury goods and then inferior goods, with new examples for each.

Chapter 3

- The Distribution of Gains and Losses from Changes in Market Conditions section includes a new sugar shock in Thailand example.
- The section on taxes has been revised throughout with new running/integrated example on cars-for-hire at two Chicago airports.

Chapter 4

- The Quantity Limits section includes a new example related to toilet paper shortage during the Covid-19 pandemic.

Chapter 5

- *Application: Engle Curves and Restaurants* has been revised to cover the disruption of the dining industry due to Covid-19 pandemic and the notion that new restaurants may predict (rather than reflect) future gentrification.
- New *Application: What the Pandemic Taught Us about Movies* is an examination of the impact of the Covid-19 pandemic on movie consumption habits, data on how the industry was impacted, and details on the growth of streaming.

Chapter 6

- The opening to the chapter and The Basics of Production section include updated examples of intermediate goods and final goods.
- *Freakonomics: Why Fishers in India Love Their Cell Phones (It's not Instagram)* has been revised for updated language and technological developments.
- *Application: Technological Change in U.S. Manufacturing* has been updated with new data and examples.

Chapter 7

- The discussion of Bitcoin mining has been updated.
- *Application: Sunk Costs on the Silver Screen: Why Studios Release Movies That They Know Will Lose Money* has been updated with new examples from the Covid-19 pandemic.
- *Freakonomics: 3D Printers and Manufacturing Cost* has been updated with new examples as well as updated prices and costs for 3D printed items.
- The new *Application: Are Rooftop Solar Panels Driving Up the Cost of Electricity?* compares the cost per kWh of rooftop solar versus large solar farms.

Chapter 8

- The *Application: Do Firms Always Maximize Profits?* has been revised to include new mention of corporate whistleblowers and fraud at the now-defunct firm Theranos.
- The If Profit Is Negative, Should a Firm Shut Down? section includes new discussion of restaurants grappling with the shutdown during Covid-19 pandemic.
- *Freakonomics: The Not-So-Simple Economics of Corporate Espionage* has been updated with new details on thieves' attempt to sell the Coca-Cola secret recipe to Pepsi.

Chapter 9

- The Switching Costs section includes a new example of the costs involved in changing from one mobile carrier to another.
- The Government Regulation section includes updated information on the new agreement between Uber and NYC Medallion Taxi industry.
- A new *Freakonomics: The Power of Market Power* explores the effects of the Russian invasion of Ukraine on the European natural gas market.
- Added examples include antitrust investigations into Apple and Amazon's practices as well the proposed (and subsequently abandoned) merger between McGraw-Hill and Cengage.
- New pharmaceutical examples include a discussion of the market for insulin and the development of Covid-19 vaccines as part of Operation Warp Speed.

Chapter 10

- New *Freakonomics: Is There a Pink Tax?*
- The discussion of price discrimination by past purchase behavior has been updated with a new example of switching costs (mobile service).
- The discussion of price discrimination over time includes updated prices and discussion of the paperback versus hardcover book market, and introduces "early adopters" and "holdouts" language to describe two groups of consumers who enter the market at different times.

Chapter 11

- Language related to oligopolistic markets, market clearing price, and Cournot competition has been clarified.
- The *Application: Cartel Bots?* has been revised for clearer discussion of AI and algorithmic pricing strategy.

Chapter 12

- The opening example has been updated to reflect changes in e-book market and related technology.
- The discussion of competing players has been updated to focus on DC and Marvel superhero franchise films.
- *Application: Vines and Vanity Projects: Wine Making for the Mega-Rich* has been updated.

Chapter 13

- The Supply in a Perfectly Competitive Factor Market section includes changes in the labor market during and after the Covid-19 pandemic.
- There is a new *Application: Electric Vehicles and Lithium.*
- *Application: Longshore Workers' Wage Premium* has been revised with updated wages, statistics, and references to supply chain disruptions during and after the Covid-19 pandemic.

Chapter 14

- A new chapter opening story is about the founding and growth of Chobani yogurt.

Chapter 15

- *Freakonomics: How What's in Your Closet Affects What's on Your Plate* has been revised.
- The explanation of pareto efficiency has been updated to improve clarity.
- *Markets, Efficiency, and the Welfare Theorems* has been updated to reflect potential reforms in Venezuela.

Chapter 16

- The Moral Hazard section has been updated with references to one-time student loan forgiveness and one-time tax holiday for repatriated corporate profits.
- Asymmetric Information in Principle–Agent Relationships has been updated to cover incentives like tips and remote work.
- The Signaling to Solve Asymmetric Information Problems section has been updated to acknowledge opportunity cost of college and to include students who finish their degrees more quickly to save money.

Chapter 17

- Discussion of pollution in chapter opening story has been expanded to include Canada as well as the United States.
- New examples of negative externalities include overprescribing of antibiotics.
- *Application: Would Higher Driving Taxes Make Us Happier Commuters?* now includes stress and road rage as externalities, with a clarified description of how driving taxes work and updated details on congestion taxes.

Chapter 18

- Discussion of behavioral economics has been updated to reflect its growing status in the field.
- Discussion of *overconfidence* and the *endowment effect* has been updated and improved, with an added emphasis on the use of scientific methods for testing behavior, including the importance of randomized testing in experimental economics.
- Revised *Freakonomics* feature includes new reference to WEIRD cultures.

About the Authors

Lumina Foundation

Austan Goolsbee is the Robert P. Gwinn Professor of Economics at the University of Chicago Booth School of Business, where he joined the faculty in 1995. From 2009 to 2011, he served in Washington as a Member and then Chairman of the Council of Economic Advisers and the youngest member of the President's Cabinet. He is a past Alfred P. Sloan Fellow and Fulbright Scholar. He earned bachelor's and master's degrees from Yale University and a PhD in economics from Massachusetts Institute of Technology.

Beth Rooney

Steven Levitt is the William B. Ogden Distinguished Service Professor of Economics at the University of Chicago, where he directs the Becker Center on Chicago Price Theory. He earned a bachelor's degree from Harvard University and his PhD from Massachusetts Institute of Technology. He has taught at the University of Chicago since 1997. In 2004, Levitt was awarded the John Bates Clark Medal, and in 2006, he was named one of *Time* magazine's "100 People Who Shape Our World." He co-authored a series of books on popular economics starting with *Freakonomics* and hosts the podcast *People I Mostly Admire*.

JasonSmith.com

Chad Syverson is the George C. Tiao Distinguished Service Professor of Economics at the University of Chicago Booth School of Business. He joined the Chicago faculty in 2001. His research spans several topics, with a particular focus on the interactions of firm structure, market structure, and productivity. He has been an editor of the *Journal of Political Economy* and *RAND Journal of Economics*, has served on multiple National Academies committees, is a research associate of the National Bureau of Economic Research, and is a Fellow of the Econometric Society. He earned bachelor's degrees in economics and mechanical engineering from the University of North Dakota, and a PhD in economics from the University of Maryland.

The Story of Microeconomics: Our Vision

We believe that microeconomics should inspire and excite students with its elegance and usefulness, and that a textbook combined with powerful assessment and resources in Achieve should support this goal.

The three of us have been friends for a long time. So why would we risk that friendship to embark on such a difficult task as writing a textbook together? We wanted to bring a different perspective to the presentation of intermediate microeconomics. We teach in economics departments and in business schools, and we are active empirical microeconomics researchers. Our experiences made us want to write a textbook that could show students how realistic theory can be if used in practical settings and make clear how economists use data and empirical analysis to test and refine theories.

For all four editions we've provided a visual cue to our approach to microeconomics: We put a Swiss Army knife on the cover of the book. The Swiss Army knife contains many tools that you can use to accomplish many varied tasks. This is how we view microeconomics:

- It introduces tools that are **fundamental** to all forms and extensions of economics, and
- It is extremely **useful** for making decisions in business, government, and everyday life.

We want to help each student grow from someone who has learned some economic principles to someone who can apply the tools of economic analysis to real situations, as economists do. And in envisioning and writing this book we wanted to deal effectively with two questions we hear regularly from students about the micro course:

Do people and firms really act as theory suggests?

All microeconomics texts present the standard tools and theory of economics, and all have examples. However, they often expect students to take on faith that these theories work. They do not always show effectively that these theories can be used in specific and practical ways.

Furthermore, continued reductions in the cost of collecting and analyzing data have led to a radical shift in microeconomics, and current texts have not fully kept up with the dramatic rise of empirical work in applied microeconomics research. Undergraduates and business school students will find microeconomics compelling if it not only explains the theory, but also demonstrates how to use it, and provides real-world data to back it up. We show students the reality behind the theory in our plentiful and up-to-date examples. We have developed and selected events, topics, and empirical studies with a clear eye toward *how* economists use real data to test and refine ideas.

How can someone use microeconomic theory in a practical way?

Students often view the intermediate microeconomics course as abstract and theoretical. Because this course requires a high degree of effort from students, they should know why and how the material they learn will be useful. Without that knowledge, they will be bored and unmotivated. So we wanted to write a book of **useful economics.** When done the right way, economics *is* extremely useful: useful for business, useful for policy, useful for life. Our book shows students how to take the tools they learn and *do* something with them.

Real World, Real Life

Microeconomics provides examples that offer unusual perspectives on the seemingly ordinary. We have been gratified by the overwhelmingly positive response to the many ways in which we integrated real-life, up-to-date, and, above all, interesting examples and *Applications* into our presentation. Instructors especially appreciated our extensive inclusion of empirical examples. All told, we have over 200 examples (20% of them new in this edition), *Applications,* and *Freakonomics* boxes that illustrate how useful the microeconomic toolbox is in illuminating and understanding all aspects of economics and life.

Our *Freakonomics* boxes, in particular, show how (in often surprising ways) economic analysis can illuminate not only common phenomena but also things not normally thought to be within the economist's purview.

Helping Students Succeed

Figure It Out exercises

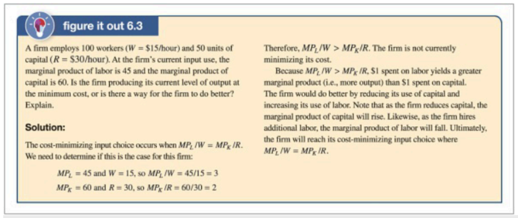


figure it out 6.3

A firm employs 100 workers (W = \$15/hour) and 50 units of capital (R = \$30/hour). At the firm's current input use, the marginal product of labor is 45 and the marginal product of capital is 60. Is the firm producing its current level of output at the minimum cost, or is there a way for the firm to do better? Explain.

Solution:

The cost-minimizing input choice occurs when $MP_L/W = MP_K/R$. We need to determine if this is the case for this firm:

$$MP_L = 45 \text{ and } W = 15, \text{ so } MP_L/W = 45/15 = 3$$
$$MP_K = 60 \text{ and } R = 30, \text{ so } MP_K/R = 60/30 = 2$$

Therefore, $MP_L/W > MP_K/R$. The firm is not currently minimizing its cost.

Because $MP_L/W > MP_K/R$, \$1 spent on labor yields a greater marginal product (i.e., more output) than \$1 spent on capital. The firm would do better by reducing its use of capital and increasing its use of labor. Note that as the firm reduces capital, the marginal product of capital will rise. Likewise, as the firm hires additional labor, the marginal product of labor will fall. Ultimately, the firm will reach its cost-minimizing input choice where $MP_L/W = MP_K/R$.

We have been especially pleased with the overwhelmingly positive responses from instructors *and* students alike to our efforts to help students hone and improve their problem-solving abilities. Students often have difficulty translating what they have learned into the ability to solve problems *using* what they have learned. To address this problem, each chapter has several *Figure It Out* exercises. These detailed, worked-out problems patiently and completely walk students through analyzing exactly what a problem asks them to do, identifying what tools they need to solve the problem, and using those tools to arrive at an answer.

Make the Grade Essays

Make the Grade essays point out common pitfalls that students may encounter, help them navigate through the finer points of microeconomic theory, and present practical advice on topics that frequently trip up students during homework and tests.

How We Deal with Math

Math is a powerful tool for economic analysis, and we want students of every skill level to be able to use it effectively. We have provided a text that will work for a diverse population of students and encourage them to use their math skills to unlock the potential of economic analysis. Our versatile text and its accompanying resources will allow you to use our book in a course with a standard algebraic and geometric focus or in one that relies more on calculus.

Our clear, accessible verbal and graphical presentations are supported by thorough, step-by-step explanations. The whys and wherefores of each step in the mathematical development of concepts are always clearly explained, and allow even math-shy students to easily understand how the use of math can enhance and simplify economic analysis. The main text uses algebra and geometry, but our in-text and online calculus appendices and accompanying resources allow calculus to be integrated easily into our book's presentation of theory, practice, and application.

Math Review

Most students entering this course will benefit from a math review, whether it is a review of basic algebra or of calculus. A *Math Review* at the back of the book provides the review necessary to prepare students for the math they will use throughout the text.

Calculus

The calculus is presented in appendices that employ the same conversational tone and intuitive approach as the text and include examples and *Figure It Out* problems (which are often the same as the algebra-based ones in the chapter). In this way, students can see how the calculus analysis buttresses the algebraic analysis. To give students an opportunity to practice what they have learned, each appendix includes problems that require the use of calculus.

To connect the material presented in the chapter with that in the calculus appendices, we have placed marginal notes in the chapter. These notes direct students to the appropriate appendix, and explain specifically how calculus will be used to understand the concepts. We hope these notes will encourage students familiar with calculus to utilize it on their own.

Calculus Appendices

2A: *The Calculus of Equilibrium and Elasticities*

3A: *The Calculus of Consumer and Producer Surplus*

4A: *The Calculus of Utility Maximization and Expenditure Minimization*
4B: *The Mathematics of Utility Functions*

5A: *The Calculus of Income and Substitution Effects*
5B: *The Calculus of Demand*

6A: *The Calculus of Cost Minimization*
6B: *The Calculus of Production Functions and Input Demands*

7A: *The Calculus of a Firm's Cost Structure*
7B: *The Calculus of a Firm's Cost Structure Expanded*

8A: *The Calculus of Long-Run Competitive Equilibria*

9A: *The Calculus of Profit Maximization*

10A: *The Calculus of Pricing Strategies*

11A: *The Calculus of Cournot and Differentiated Bertrand Competition Equilibria*

12A: *The Mathematics of Mixed Strategies in Game Theory*

How Our Book Is Organized

Here is a brief snapshot of the chapters in the book with a bit of discussion on particular subjects that received some special attention or might be different from what you would find in other books. We consider Chapters 1–11 the core chapters that most instructors will teach. The remaining chapters, 12–18, can be taught independently of one another.

Chapter 1, Adventures in Microeconomics:

We open the book with a brief introductory chapter and a story about the markets for making and for buying coffee to entice and excite students about the study of microeconomics. Through an *Application,* a *Make the Grade* essay, and a *Freakonomics* box, we show students right away how microeconomic tools are useful, not just in the study of economics and business, but in everyday life.

Chapter 2, Supply and Demand:

In Chapters 2 and 3, we lay a solid foundation by going deeply into supply and demand before moving on to consumer and producer behavior. Most microeconomics texts separate the presentation and the application of this simple yet powerful model. Presenting the entire model at the beginning makes logical sense, and we (and those who have used our book) have experienced success with this approach in classes.

Chapter 2 presents the basics of the supply-and-demand model. Of particular note is the section Key Assumptions of the Supply and Demand Model, which exemplifies the care and clarity with which we develop and explain microeconomic theory.

Chapter 3, Using Supply and Demand to Analyze Markets:

In Chapter 3, we use the supply-and-demand model to analyze extensively consumer and producer surplus, price and quantity regulations, and taxes and subsidies. We believe that the earlier these concepts are introduced and the more completely they are explained, the easier it is to use them throughout the course. Chapter 3 is designed to be flexible: You can pick and choose which topics to cover and emphasize.

Chapter 4, Consumer Behavior:

How do consumers decide what and how much to consume given the enormous variety of goods and services available to them? We begin this crucial chapter by clearly laying out, in one section, the assumptions we make about consumer behavior. Actual tests among professors consistently showed this approach as being especially helpful for their students.

Chapter 5, Individual and Market Demand:

Here we show how consumer preferences are used to derive market demand. Section 5.3, Consumer Responses to Price Changes: Substitution and Income Effects, takes extra care in explaining this topic, which students often find challenging. Abundant applications and a discussion of pitfalls to avoid make this material particularly accessible and interesting.

Chapter 6, Producer Behavior:

How do companies decide which combination of inputs to use in production, and how does this decision affect production costs? We begin this chapter by clearly laying out the Simplifying Assumptions about Firms’ Production Behavior. Later in the chapter, we devote a complete section to the role technological change plays in firms’ productivity over time. Several applications and examples bring this material alive for students.

Chapter 7, Costs:

Cost curves illustrate how costs change with a firm’s output level and are crucial in deriving market supply. Because opportunity costs and sunk costs are often difficult concepts for students to master, we take extra care at the start of Chapter 7 to distinguish these concepts and illustrate the role they play in decision making. Our examples engage students so that they can better understand the often challenging concepts in this chapter.

Chapter 8, Supply in a Competitive Market:

This chapter begins our coverage of market structure, and it uses real-life industries such as the Texas electricity industry to explain how competitive markets work. We clearly, carefully, and patiently explain a firm’s shutdown decision, a topic that students often find confusing.

Chapter 9, Market Power and Monopoly:

This chapter begins with a thorough discussion of the origins of market power and how having such power affects a firm’s production and pricing decisions. We bring the concept of monopolistic market power to life using examples of real firms with near-monopoly power, such as Durkee-Mower, Inc.; the firm that makes Marshmallow Fluff; and Dr. Brown’s, a manufacturer of specialty sodas. Abundant applications further engage students’ interest.

Chapter 10, Pricing Strategies for Firms with Market Power:

This practical chapter will appeal especially to business students. We thoroughly discuss the many ways in which a firm can take advantage of pricing power, and we clearly describe which pricing strategies are useful in which situations.

Chapter 11, Imperfect Competition:

This chapter looks at oligopolies and monopolistically competitive firms. Unlike perfectly competitive and monopolistic firms, these firms must consider their competitors' actions and strategize to maximize their profits.

Chapter 12, Game Theory:

The tools of game theory can be used to explain strategic interactions among firms and to predict market outcomes. Students will find our game theory analysis (presented in one chapter for better comprehension) easy to follow and understand. Varied topics from penalty kicks in soccer to airlines' responses to threats of entry show the usefulness of game theory not just in business, but also in everyday decision making.

Chapter 13, Factor Markets:

This chapter covers many features of factor markets. To make the concepts more concrete, we use the labor market as an example in much of the development, but we also discuss the unique features of other factor markets. Factor demand and supply are built up from the individual firm or worker level, and then aggregated to an industry equilibrium.

Chapter 14, Investment, Time, and Insurance:

Understanding the role of risk and uncertainty over time helps individuals and firms make better economic decisions about investments and insurance. We clearly explain how current costs, future payoffs, time, and uncertainty play a fundamental role in the many decisions firms and consumers face every day. Reviewers especially appreciated our coverage of all these topics in one concise chapter.

Chapter 15, General Equilibrium:

We explain intuitively the concepts of general equilibrium, using an extension of the supply-and-demand framework. We also explain the connections among exchange, input, and output efficiencies and tie them to the Welfare Theorems.

Chapter 16, Asymmetric Information:

After discussing in earlier chapters what conditions must hold for markets to work well, we look at situations in which markets might not work well. Chapter 16 shows how market outcomes are distorted when information is not equally shared by all potential parties in a transaction. As always, a variety of examples, from auto insurance to credit cards to pirates, shows students that concepts learned in microeconomics are useful in many areas of life.

Chapter 17, Externalities and Public Goods:

This chapter continues our examination of market failure by looking at what happens to market outcomes when transactions affect people who are neither the buying nor the selling party, and what happens when a good's benefits are shared by many people at the same time. Our coverage makes clear to students why externalities occur and how they can be remedied.

Chapter 18, Behavioral and Experimental Economics:

The recent growth of behavioral economics poses a challenge to traditional microeconomics because it questions whether people actually behave the way traditional theory predicts they will. This question presents any intermediate microeconomics book with a conundrum because embracing behavioral economics seems to undermine the methods learned in the book. Our chapter on behavioral economics explains how to think rationally in an irrational world. If some people make irrational economic decisions (and we present the behavioral evidence of situations in which they tend to make mistakes), other market participants can use this irrationality to their advantage.

With Gratitude

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We are grateful to the many people at Worth who provided the knowledge and support needed to get this book into your hands. Intermediate microeconomics is a hands-on course for instructors and students, and there is a great need for quality instructional and learning tools to enhance their experiences in and out of the classroom. In editorial, Lukia Kliossis, Joshua Hill, Kristyn Brown, Nick Rizzuti, Stephanie Sosa, and Amanda Nava expertly managed all of the content found within the text and Achieve. In production, we thank Gregory Erb for seeing our manuscript through the production process with superior attention to detail. We thank Deborah Heimann, our copyeditor, for her careful eye. Cover Designer, John Callahan, and Design Manager, Natasha Wolfe, made the book look great. Robin Fadool worked hard to find interesting and entertaining photos for many of the chapters. We would also like to thank Marieta Velikova for her careful eye in accuracy checking the entire text for this edition.

Final Thoughts

Heartfelt thanks to our families for their continued support of our work (especially when we are too busy to let them know how much we appreciate it).

Ultimately, any text is only a tool and a complement to what students learn in the classroom and from one another. We hope that this text will help you to start them on that journey to using economics.

Austan Goolsbee **Steven Levitt** **Chad Syverson**

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CHAPTER 1

Adventures in Microeconomics

1.1 Microeconomics (and What It Can Teach Us about Rosa and Lauren)
1.2 This Book (and How Rosa and Lauren Would See It)

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The ripe coffee "cherry" and savory cappuccino are two sides of the same market.

It is morning in Peru's Selva Alta hills, and the sun has been up for a few hours. Rosa Valencia looks admiringly at the coffee plants she's grown. The coffee plants' fruits, called *cherries* because of the red hue they take on when ripe, are ready for harvest. Rosa's workers handpick the fruit and carry it to the outbuilding where it is processed. There, other workers sort the cherries, then remove the fruits' flesh to expose the two seeds—the coffee beans—inside. The beans are washed and prepared for drying and roasting.

That same morning, about 5,000 miles away in Seattle, Washington, home of Starbucks, Lauren Reyes grapples with a physics problem. She's at her favorite coffee shop, a block off campus, for her midmorning break. Sitting on the table next to her book is her usual, a skinny cappuccino. Every few moments, between calculations, Lauren takes a sip and savors the deep, rich flavor of the coffee.

Lauren and Rosa have never met, and likely never will. Yet, their morning routines are connected because the two women are part of the same market, the market for coffee. Lauren's taste in drinks connects her to Rosa, who provides a critical input for that drink. Both women benefit from this connection: Rosa profits from growing coffee, and Lauren gets a cappuccino at a price she is willing to pay. This is microeconomics at work.

1.1 Microeconomics (and What It Can Teach Us about Rosa and Lauren)

Rosa and Lauren's connection is the consequence of a large number of decisions and transactions that combine to convince Rosa that growing coffee is worth her time and effort, and convince Lauren that her skinny cappuccino is worth the money. This book investigates those many decisions and transactions, and how they interact in markets.

We will look at these decisions through the framework of *micro*economics. **Microeconomics** is the branch of economics that studies the specific choices made by consumers (like Lauren) and producers (like Rosa). In contrast, *macro*economics looks at the world through a wider lens and is a description of the larger, complex system in which consumers and firms operate. Macroeconomics takes hundreds of millions of individual producers and consumers like Rosa and Lauren, and tries to describe and predict the behavior and outcome of the combined total of their individual decisions. In this book, we steer clear of the macroeconomic questions.

microeconomics
The branch of economics that studies the specific choices made by consumers and producers.

Although the basic outline and content of this course are similar to those of a principles of microeconomics course, there are some important differences. First, we incorporate mathematics into our models along with graphs. At its heart, economics is concerned with resource allocation, so we want to be able to create precise models that can be solved for optimal quantities. For example, we often want to know exactly how much of a good a consumer will want to consume to maximize their happiness (utility) given that they have limited income. We also want to model how a firm maximizes its profit when choosing its output level and the amounts of inputs it uses to make that quantity of output. Although graphs and verbal explanations are helpful, using math allows us to better quantify these economic agents' decisions.[1]

Second, in intermediate microeconomics, the level of analysis is deeper than in a principles of microeconomics course. We don't take relationships such as the law of demand or the law of supply for granted. We examine the details of *why* the relationships exist and when they don't apply.

Finally, intermediate microeconomics has a greater policy focus than a principles of microeconomics course does. Understanding the economic behavior of consumers and producers is the key to developing appropriate policies. We can also use this deeper knowledge to attempt to predict how various policies (proposed or in place) alter individuals' and firms' incentives and change their behaviors.

Learning the Tools of Microeconomics

What sorts of tools will we learn to use as we explore the study of microeconomics? We always start with **theories and models**, explanations of how things work that help us understand and predict how and why economic entities (consumers, producers, industries, governments, etc.) behave as they do. To learn the intricacies of the theories and models, we use the tools of graphs and mathematics.

theories and models
Explanations of how things work that help us understand and predict how and why economic entities behave as they do.

We then use the theories and models to look at how people and firms actually behave in real life (including some seemingly noneconomic situations). The interaction between microeconomic theory and the events, decisions, and empirical data from the real world lies at the heart of microeconomics. Each chapter includes the following sections that illustrate this interaction:

- *Application* sections help us understand theory at work by showing how microeconomics can be used to inform economic decision making in a variety of interesting, real-world situations. Want to know about the effect of toxic algae in Florida? Or, whether or not animals care about fairness? Or, how and why consumers and producers act as they do in the markets for housing, movies, electricity generation, soybeans, video games, and avocados? Some applications delve into the specifics like these of how consumers and producers act in real life. Other applications look at current microeconomic research to see how the data gathered by microeconomists inform and test the predictions of theory across a wide range of topics, such as golf tournaments, rooftop solar panels, the use of gym memberships, a patent's duration of time, and cancer drug development.

- *Freakonomics* essays reveal the surprising ways in which economic analysis provides a unique perspective for exploring a huge variety of phenomena in the world around us. These essays look at topics as diverse as a homemade toaster and why fishers love their cell phones. Such stories give us a framework for thinking about the economic phenomena that surround us.

FREAKONOMICS

Thomas Thwaites's Toaster

Thomas Thwaites must really like toast.

Not content simply to buy a toaster to make his toast, Thomas Thwaites set out on a mission to make a toaster from scratch. He started with the raw materials, gathering copper, mica, nickel, and oil (to make plastic), some of which he extracted himself from abandoned mines in the English countryside. He even adapted a microwave oven to smelt the iron ores needed for the toaster's grill and spring. In the end, his homemade contraption was indeed capable of making toast about as well as any cheap toaster sold in stores. If you factor in time, effort, and money spent, Thwaites's toaster cost thousands of times more to make than a store-bought version does.

It should not have come as a surprise to Thwaites that making a toaster from scratch would be hard work, at least not if he knows anything about economics. Think about the goods and services you've consumed so far just *today,* and all the different materials, technology, workmanship, and coordination that went into making them. The modern economy is nothing short of miraculous. All of us—Thwaites included—have become completely dependent on the market's amazing ability to deliver a nearly infinite variety of products to us at a tiny fraction of the cost and effort it would take us to produce them ourselves.

Compared to other things we use as consumers, a toaster is fairly simple. Imagine trying to build a computer or an automobile completely from scratch, starting from the rawest materials. Even making your own dinner would be life-consuming if you had to grow (or if you eat meat, raise) all the ingredients yourself.

No doubt Thomas Thwaites's toaster experiment taught him—the hard way—about the modern economy. If his goal is to learn economics, we suggest a different approach the next time he gets a craving, say, for ice cream. Rather than raising cows, growing sugarcane, hand harvesting vanilla beans, and combining, churning, and freezing it himself, we suggest he visit his local convenience store and enjoy some store-bought ice cream while he reads Chapter 2 of this book.

Thomas Thwaites

Thomas Thwaites's Toaster Project

A very expensive toaster.

Using the Tools of Microeconomics

An old joke tells of a tourist looking for a famous concert venue in New York City, who asks a local, "How do you get to Carnegie Hall?" "Practice, practice, practice," the New Yorker replies. So it is with microeconomics. Practice with using the tools of microeconomics is how you get good at it, and there's plenty of help on this front as you progress through this book.

- In each chapter, you will find several worked out problems titled *Figure It Out* (see Chapter 2 for an example). These problems are typical of the problems you will encounter in your homework sets, quizzes, and exams, and they appear throughout the chapters to illustrate how to translate your understanding of theory, graphs, and mathematics into successful problem-solving skills. Each Figure It Out shows you, step-by-step, how to understand what, exactly, a problem is asking you to do, and then how to solve it using the tools you've just learned.
- At the end of each chapter, you will find a set of *Problems* to solve. The variety of problems will prepare you well for applying the tools you've learned to new situations, scenarios, and dilemmas. You should try to solve as many of these

problems as you can, and for selected problems, you can check your answers with the solutions provided at the end of the text. If you get stuck on a problem, go back through the Figure It Out examples to review the steps you should take to solve for the correct answer.

- In many chapters, you will find a *Make the Grade* box with hints and explanations about how to successfully navigate the sometimes confusing path through microeconomic theory and its application. Read these boxes carefully before exams and quizzes to help you avoid some common mistakes that students often make in an intermediate microeconomics course.

make the grade

Holding the rest of the world constant

As you have probably seen in your previous economics courses, economists often use simplifying assumptions in their models to make the world an easier place to understand. One of the most important assumptions we use time and time again in this text is *ceteris paribus*—that is, "all else is equal." For example, suppose you are contemplating your friend Max's demand for an ice cream cone and considering how his demand is affected by an increase in the price of an ice cream cone. To see this impact, you need to hold constant everything else that may influence Max's decision: the amount of money he has, the outside temperature, the prices of other things Max buys, even his preferences for ice cream itself. This "all else equal" assumption then allows you to focus on the factor that you are interested in, the *price* of an ice cream cone.

It is easy to get tripped up on this assumption when you're asked to dissect an application or an example, so be careful! Don't read more into a scenario than the facts you are given, and don't drive yourself crazy by dragging into the problem all kinds of hypothetical situations beyond those provided in the problem you are analyzing (e.g., What if Max is lactose intolerant? What if it's a cold, windy day? Or, what if Max just lost his job?).

It is also important to remember that the "all else equal" assumption applies, in addition, to the goods we are considering. When we talk about a particular good, we assume that all units of that good are the same; that is, we hold all the characteristics of the good constant. This means that when we talk about ice cream cones, we are talking about cones of a particular size and quality. Do not think that the price of an ice cream cone has risen if the ice cream inside it is now a premium brand, or if the same ice cream now comes in a chocolate-dipped waffle cone. By introducing either of those changes, you're changing the nature of the good itself, not just its price. By allowing something other than the cone's price to change, you would be violating the "all else equal" assumption.

Left: M. Unal Ozmen/Shutterstock; right: wildarrow/iStock/Getty Images

Things are not held constant between these two cones.

1.2 This Book (and How Rosa and Lauren Would See It)

We begin our investigation of microeconomics with an overview of how the preferences of consumers like Lauren (the demand side of a market) combine with the decisions of firms like Rosa's coffee plantation (the supply side) to determine the quantity sold and price of goods such as coffee (Chapters 2 and 3). We explore, for example, why consumers' and suppliers' responses to price changes differ, and how these differences affect what happens when consumer preferences or production technologies change. And we see how the benefits of a market transaction, such as buying a cappuccino, are split between consumers like Lauren and producers like the coffee shop and Rosa.

Consumers' and Producers' Decisions

After taking this overview, the next section of the book digs a lot deeper into each side of the market, starting with consumers' decisions (Chapters 4 and 5). What determines whether Lauren has coffee instead of tea, or if she goes to a shop other than Starbucks, or does something else entirely? If Lauren becomes richer, will her choices change? We answer the question of how consumers decide which goods, and how much of each, to consume in the face of the enormous number of goods and services they are offered. Then we see how adding up these decisions across all consumers gives us the total market demand curve.

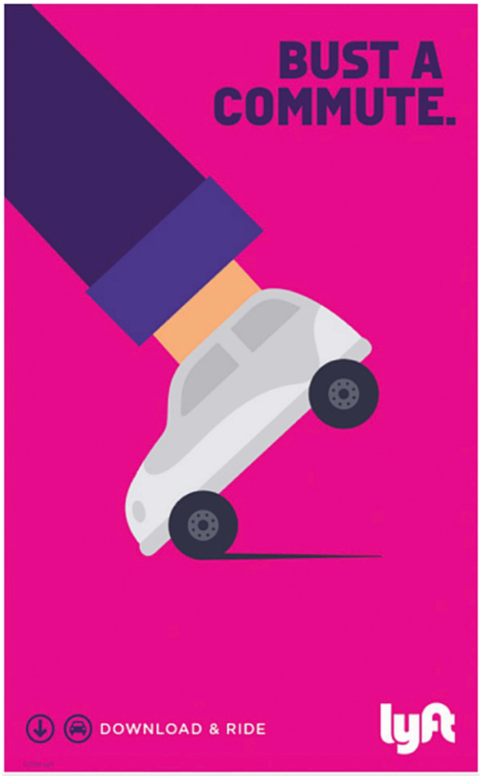
After investigating consumer behavior in detail, we explore producers' decisions (Chapters 6 and 7). For example, how do companies like Rosa's plantation decide which combination of inputs such as agricultural machinery (capital) and workers (labor) to use in production? As it turns out, those types of decisions for firms are similar in many respects to the decisions consumers make when deciding what products to buy. Once we've described firms' input mix choices, we look at how these affect their costs of production. We pay particular attention to how these costs change with a firm's output level, as embodied in firms' cost curves. If Rosa doubles her production, for example, will her total costs double, more than double, or less than double? We focus on cost movements as a firm's output changes because they are crucial in determining what a market's supply curve looks like.

Application: Rideshare Driving the Microeconomics Way

In microeconomics, we focus in large part on two key economic players: consumers (buyers) and producers (firms). We all have ample experience as consumers. Every time we go to the supermarket or the college bookstore, we are consumers. This makes it easier to grasp the economic intuition of the consumer's problem. It's often more difficult to understand producers and the issues they face because the majority of us will make far fewer production decisions over our lifetimes.

When we think about production, big firms like Nike or United Airlines might come to mind. But there are also many small producers who face the same fundamental decisions that are confronted by the world's largest corporations. Let's look at the production decisions a driver for a ridesharing service faces.

Suppose you are interested in working as a driver for one of these alternatives to taxicabs. The first decision you need to make is which ridesharing company to affiliate with. Uber and Lyft are the two biggest companies, so many drivers consider these to be their principal options. Uber is larger and aims to be slightly more upscale (the business requires the driver to have a newer-model car, offers limo/sedan services and the like); Lyft sells itself as fun and cool, with drivers sometimes greeting customers with fist bumps. You must decide at which company you are likely to make more income. Both companies require you to use you own vehicle, for which you will pay for insurance, fuel, and maintenance. And both will take a share of each fare you receive and charge you certain mandatory fees (for instance, for a company-specific phone on which you must take all customer calls). You might try to work for both companies, switching between the two based on the fares you expect to receive. Or you might decide to avoid dealing with passengers altogether, and switch to making deliveries via UberEats or another service such as DoorDash or GrubHub.



Deciding whether to drive for Uber or for Lyft is only one of many decisions you will make.

Once you're signed up, you need to determine the quality and frequency of service you will provide. There are many variables to consider, from whether to work nights and weekends to whether to engage your passengers in conversation or play the radio instead. Your customers' experiences will influence your ratings as a driver and the probability that you get more business in the future. You will also face some decisions about the longer term, perhaps choosing an electric vehicle (EV), which would cost less to run than your current car, making each ride more profitable. Although you can decide to chat up one customer and not the next with little impact, you cannot simply stop making payments on a new electric car should you decide a chauffeur's life is not profitable enough for you. Here, you will have to consider how the rideshare company may fare in the future to decide if an expensive EV would be a worthwhile investment.

These examples of the many production decisions you'll face all share a basic principle: They require you to determine whether the costs (financial, time, or effort) of your decision will bring in enough additional revenue to make your choice worthwhile. As you will see in this text, the tools of microeconomics let you and all producers frame the decisions in a way that makes it clearer what the better choice is.

The microeconomics of production decisions may not come as easily to you as the microeconomics of consumer decisions, but understanding the production side of things will help you make more informed and perhaps wiser choices should you find yourself running your own or someone else's business. ■

Market Supply

The book's next section compares many possible configurations through which firms supply output to markets. We start with the canonical case of perfect competition (Chapter 8). In a perfectly competitive market, all firms take the market price as given (they don't have any ability to choose the price at which they can sell their products) and decide how much they want to produce. This is close to Rosa's case. The international coffee market is large and supplied by coffee growers all over the world, so how much coffee Rosa decides to put on the market is not going to noticeably affect its market price. In a perfectly competitive industry, supply reflects the aggregation of the cost curves of Rosa and every other coffee grower, and industry supply combines with market demand to determine price and quantity movements over both the short and long runs.

After perfect competition, we move to the other extreme: monopoly (Chapter 9). When only one firm supplies a good to a market, the situation differs in several ways from perfect competition. Key is that the firm now has the ability to choose the price at which it sells its products. We see that this ability implies that if Rosa were a monopolist selling to the world's coffee consumers, she would choose to produce less than a competitive industry would—even if she had the capacity needed to produce more. This is because limiting the amount she produces raises the price at which she could sell her coffee. We see why governments might want to (and sometimes do) step into such situations using antitrust laws. Next, we discuss other ways monopolists use their pricing power (Chapter 10). This includes ways to charge higher prices to consumers with a greater willingness to pay, or combining products together and selling them as a single bundle to consumers.

In the book's final look at forms of a market's supply side, we investigate oligopolies (Chapter 11). Oligopolies exist when multiple firms interact strategically in the same market. In such markets, firms have some ability to choose their prices, but their fortunes are determined, in part, by the actions of the other firms in the market. (They dish it out as well as they take it, though: Their own actions also impact other firms.) These sorts of situations are common; few firms are either pure monopolists or perfectly competitive price takers. Strategic interactions among firms raise all sorts of interesting questions that we can analyze using the tools of game theory (Chapter 12). For example, how might we expect a firm like Lauren's favorite coffee shop, say, to respond to a new coffeehouse opening across the street?

Beyond the Basics

After these detailed looks at the basics of markets' supply and demand sides, we study several specific subjects in the final section of the book. The economic concepts covered here are present in many markets. In some applications, these concepts deepen our understanding of markets by supplementing the basic analytical structure we introduce in the first parts of the book. In other cases, the basic structure may be inadequate to grasp all the necessary elements of economic interactions, so these concepts will be absolutely necessary to understanding the behavior of particular markets.

The first specific topic we dig into is how factor markets operate (Chapter 13). Factors are inputs into production, such as labor, capital, and land. These markets interact with the decisions of producers like Rosa's plantation to determine where workers work and for what wage, and where factories are built.

Next, we look at the combined role of risk, uncertainty, and time in economic decision making (Chapter 14). These features are especially prominent in investment decisions—choices that typically involve paying an upfront cost with the hope of earning a positive future return—so these decisions are a focus of our exploration. Understanding risk, uncertainty, and time's interactions in investment choices helps us answer questions such as whether Rosa should invest in a new bean-drying facility, or whether Lauren should go to business school.

We then explore how markets are interconnected (Chapter 15). Changes in the supply or demand of one good can lead indirectly to similar or opposite shifts in other markets. After studying this interconnectedness, we are able to see how a supply disruption in China's tea-growing areas can raise the price at which Rosa will sell her coffee and the price that Lauren must pay for her cappuccino. Once we're able to tie markets together, we can analyze the conditions that must hold for an economy to operate efficiently. For example, are producers supplying the "right" mix of coffee and tea, and doing so at the lowest possible cost? Answering such questions allows us to determine whether markets are working to maximize the social benefit of a good or service.

After seeing what must hold for markets to work well, we look in detail at a series of situations in which markets might *not* work well. One set of situations involves markets in which information about tastes, costs, or product quality is not equally shared by all potential parties in a transaction (Chapter 16). For example, if Rosa wants to buy a used tractor for the plantation, she wouldn't know with 100% accuracy how well the tractor works before buying it, and she might be especially concerned that the current owner was selling the tractor precisely *because* it didn't operate up to par. How does this lack of accurate information affect her decision? Or, if Lauren wants to convince a potential employer she would be a hard-working employee before she gets the job, how might she do so?

A second set of situations in which markets may not operate efficiently includes transactions that affect people who are neither the buying nor the selling party, or markets in which a good's benefits are shared across many people at the same time (Chapter 17). An example would be Rosa's decision whether or not to apply pesticides to her crop. Doing so would not only affect the economics of her own operation, but would also have spillover effects on others. A neighboring coffee plantation might benefit from facing a smaller population of local insects, for instance. On the other hand, other neighbors, workers, and maybe coffee consumers could be harmed by the chemical pollution that pesticide use involves. What makes these situations interesting—and what causes markets to have difficulty delivering the socially optimal outcome—is that Rosa is likely to take into account the pesticide's impact on her own production when deciding whether to use it or not, but is less inclined to consider its effects on neighboring farms, the local population, and coffee drinkers in Seattle.

The book concludes with an exploration of behavioral economics (Chapter 18). This study of the intersection of psychology and economics has become an increasingly prominent part of economic research. People often have deeply formed biases and social preferences that limit their ability to act in the completely rational, self-interested way that we often assume in economic analysis. If this is true, then our basic analytical structure—even when supplemented with knowledge of the deeper concepts discussed above—may be inadequate for explaining economic decision making.

Focus on Data

All these topics provide you with microeconomic tools to study the world around you. Over the past 50 years, this set of tools has expanded and changed. Microeconomics has evolved into a more **empirical** discipline, using data analysis and experiments, and not just abstract theory, to explore economic phenomena. The computing revolution made this change possible. As you'll see throughout this book, when the price of a good decreases, people consume more of it. This has been true of computing. Much more of modern-day economists' efforts toward understanding the economy center on data and measurement than they did just a few decades ago.

empirical

Using data analysis and experiments to explore phenomena.

Let the Fun Begin!

By the end of your microeconomics course, you will have the resources necessary to examine the world as an economist does. We've already used microeconomic tools to broadly describe a very specific economic exchange between coffee producer Rosa and university student Lauren. But what's powerful about microeconomics is that it can be applied to any market, not just to a market like the one inhabited by Rosa and Lauren. You can use microeconomics to think rationally about any of the dozens of choices (economic and noneconomic) you face each day. By the end of your study of intermediate microeconomics, you'll not only *be able to think* like an economist—you'll *see how useful* it is.

Application: The Benefits of Studying Economics

There are many reasons to study economics. Maybe you are one of the lucky few with a burning passion to understand economics. Or, maybe you just need an economics course to graduate. Either way, you will learn a set of tools in this class that will better equip you to make all sorts of decisions, not just economic ones. There's even evidence that if you become an economics major, it will make you richer.

Economists Dan Black, Seth Sanders, and Lowell Taylor analyzed the question of how much people earn depending on their choice of major.[2] They approached the question in typical economic fashion: with a sizable dataset and quantitative statistics. Using the National Survey of College Graduates combined with information from the U.S. Census, they found that economics majors earn almost 20% more than graduates with degrees in any of the other social sciences. (Accounting, finance, and marketing students do earn about the same as economics majors.) Music majors don't fare so well in salary terms: Their incomes are approximately 40% lower than those of economics majors.[3]

One thing you might worry about in this analysis is whether it is actually learning economics that leads to higher wages, or perhaps just that the kind of people who major in economics are different from, say, sociology majors, and would have earned more money, regardless of what they studied. To at least partially address that critique, Black, Sanders, and Taylor took a look at earnings within narrower career paths. For instance, looking only at students who go on to law school, they determined that those who studied economics as undergrads earn more than students with other majors—up to 35% more, in the case of former sociologists. An economics degree is similarly beneficial to those who eventually pursue an MBA.

We hope that you will be so enthralled by economics that you want to make it your focus. But if you are in it just for the money, you could do worse.

Summary

1. **Microeconomics** relies on **theories and models** to study the choices made by individuals and firms. Intermediate microeconomics builds on the principles of microeconomics course by adding mathematical models to the examination of consumer and producer behavior. Practicing the mathematics underlying microeconomic theory is the key to becoming a skilled economist. In addition, intermediate microeconomics has a strong focus on policy and its effects on behavior. **[Section 1.1]**
2. Microeconomics looks at a variety of decisions made by consumers and producers as they interact in the markets for goods and services, and at the different market structures in which consumers and producers operate. A wide range of topics deepens our understanding of the microeconomics of consumer and producer interaction, including risk and uncertainty, the role of information, and the study of behavioral economics. In recent years, microeconomics has evolved from a discipline that relied primarily on theory to one based on **empirical** studies (data analysis and experiments). **[Section 1.2]**

Review Questions

1. What differentiates microeconomics from macroeconomics?
2. Name one instance in which you were a *consumer*.
3. Name one instance in which you were a *producer*.
4. How are consumption and production interconnected?
5. What tools do we use to study microeconomics?
6. Why has microeconomics evolved into an empirical discipline?

CHAPTER 2
Supply and Demand

2.1 Markets and Models
2.2 Demand
2.3 Supply
2.4 Market Equilibrium
2.5 Elasticity
2.6 Conclusion
Appendix 2A The Calculus of Equilibrium and Elasticities

When the Covid-19 pandemic forced offices around the world to shut down, a large number of office workers suddenly became remote workers, moving their workspaces out of commercial office buildings and into their own homes. From spare bedrooms and dens, dining room tables and living room corners, workers and managers figured out how to get things done when everyone wasn't all in one place.

While the pandemic's gradual regression will bring workers back to their office for at least part of the time they used to spend there, it is widely expected that many workers will opt to continue working remotely, and so their companies won't need as much office space per employee as they did before. In economists' language, this pandemic-fueled shift toward remote work reduced companies' demand for office space.

Commercial landlords look at this shift with anxiety. As the suppliers of office space, they realize that the reduced demand for the product they sell is not an encouraging development. They have limited ability to renovate their buildings for uses other than as offices, so the reduced demand for office space means they may be taking the Covid-19 punch right on the chin, in terms of lower prices for their product.

In this chapter, we explore these forces, the two most powerful forces in economics: supply and demand. We answer the most fundamental question in economics: *How do consumers and producers interact in the market for a good or service to determine how much is sold and at what price?*

2.1 Markets and Models

Modern economies are amazingly complex. Producers from all over the world offer close to unlimited varieties of goods and services that consumers can purchase. A large supermarket will have more than 100 different kinds of cold cereal on the shelf. There are thousands of degree-granting colleges and universities. On any given day, millions of items are for sale on Amazon or eBay. With over 8 billion people in the world, each of them with different tastes and incomes, and tens of millions of businesses supplying goods and services, how do consumers decide what products, and how much of each, to buy? How do producers know what products to produce? And who decides at what price the products sell?

Answering these questions seems hopelessly complex. Indeed, if we tried to tackle them all at once, it *would* be hopeless. Instead, we follow the economist's standard approach: **Simplify the problem until it becomes manageable.**

The *supply and demand model* represents the economist's best attempt to capture many of the key elements of real-world markets in a simple enough way that we can analyze it. **Supply** is the combined amount of a good that all producers in a market are willing to sell; **demand** is the combined amount of a good that all consumers are willing to buy. The idea of a "market" is central to economics.

supply
The combined amount of a good that all producers in a market are willing to sell.

demand
The combined amount of a good that all consumers in a market are willing to buy.

What Is a Market?

In the strictest sense, a market is defined by the specific product being bought and sold (e.g., oranges or Bitcoin), a particular location (a mall, a city, or the Internet), and a point in time (January 4). In principle, the buyers in a market should be able to find the sellers in that market, and vice versa, although it might take some work (what economists call "search costs") to make that connection.

In practice, the kinds of markets we talk about tend to be broadly defined. They might be broad in terms of the product (e.g., all groceries rather than just oranges), the location (often we consider all of North America or even the world as the geographic market), or the time period (annual sales rather than by day). These broader markets are often of more interest and result in more data to analyze, but as we will see, defining markets too broadly can make the assumptions of the supply and demand model less realistic. Thus, we face a tradeoff between studying small, less consequential markets that closely match the underlying assumptions and broader, more important markets that do not.

Key Assumptions of the Supply and Demand Model

There are four basic assumptions that underpin the supply and demand model (summarized in **Table 2.1** below). Although actual markets usually don't perfectly conform to all these assumptions, the supply and demand model has proven to be remarkably useful for thinking about how markets work.

1. **We restrict our focus to supply and demand in a single market.** The first simplifying assumption we make is to look at how *supply* and *demand* interact *in just one market* to determine how much of a good or service is sold and at what price it is sold. In focusing on one market, we won't ignore other markets completely—indeed, the interaction between the markets for different kinds of products is fundamental to supply and demand, and we'll discuss it in a later chapter. For now, however, we only worry about other markets if they influence the market we're studying and we ignore any impact of our market on other markets.
2. **All goods bought and sold in the market are identical.** We assume that all the goods bought and sold in the market are homogeneous, meaning they are identical, so a consumer is just as happy with any one unit of the good (e.g., a gallon of gasoline is fairly homogenous regardless of the seller).[1] These are **commodities**, goods that are traded in markets where consumers view different varieties of the good as essentially interchangeable. Goods such as wheat, soybeans, crude oil, nails, gold, or #2 pencils are commodities. Custom-made jewelry, cars, video games, the different offerings on a restaurant's menu, and wedding dresses are not commodities because the consumer typically cares a lot about specific varieties of these goods.
3. **All goods sold in the market sell for the same price, and everyone has the same information about prices, the quality of the goods being sold, and so on.** This assumption is a natural extension of the identical-goods assumption, but it also implies that there are no special or secret deals for particular buyers and no quantity discounts. In addition, everyone knows what everyone else is paying.
4. **There are many buyers and sellers in the market.** This assumption means that no one consumer or producer has a noticeable impact on anything that occurs in the market and on the price level in particular. This assumption also tends to be more easily justified for consumers than for producers. Think about your own consumption of bananas, for instance. Whether you stopped eating bananas altogether or quadrupled your banana spending, your decision would not affect the banana market as a whole. On the producer side, however, most bananas (and many other products) are produced by a few big companies. It is more likely that decisions by these firms about how much to produce or what markets to enter will substantially affect market prices and quantities. We're going to ignore that possibility for now and stick with the case of many sellers. Starting in Chapter 9, we analyze what happens in markets with one or a few sellers.

commodities
Goods traded in markets where consumers view different varieties of the good as essentially interchangeable.

Notice that the assumptions of the supply and demand model are somewhat unrealistic. Few of the markets in real life fully satisfy them. It turns out, however, that a strength of this model is that when some (or even most) of the specific assumptions of the model fail, it still manages to provide a good description of how markets work. No model is perfect, but the supply and demand model has survived the test of time and is the workhorse of economics. Developing a deep understanding of the basic supply and demand model is one of the most important economic tools you can have, even if it does not perfectly fit every market. Plus, economics isn't completely wedded to the most stringent form of the model. Much of the rest of this book, and the field of economics more generally, is devoted to examining how changing the model's assumptions influences its predictions about market outcomes.

Having made these assumptions, let's see how they help us understand how markets work, looking first at demand and then at supply.

Table 2.1 The Four Key Assumptions Underlying the Supply and Demand Model

1. We focus on supply and demand in a single market.
2. All goods sold in the market are identical.
3. All goods sold in the market sell for the same price, and everyone has the same information.
4. There are many producers and consumers in the market.

2.2 Demand

Pike Place Market, one of the best-known public markets in the world, spans several blocks in the northwest corner of downtown Seattle. It has operated continually since 1907, and on any given day hosts hundreds of vendors selling everything from fish and meat to produce and flowers to crafts and antiques. Approximately 10 million people a year visit the market.

Factors That Influence Demand

Tomatoes are a popular item for shoppers at farmers' markets like Pike Place. All sorts of factors influence how many tomatoes consumers purchase there. Let's discuss the most important.

Price

The price of tomatoes is probably the most important consideration. Few consumers would pay $40 per pound for tomatoes, but many would pay $1 a pound.

The Number of Consumers

All else equal, the more people there are in a market, the greater the quantity of the good desired.

Consumer Income or Wealth

As a consumer becomes richer, they will buy more of most goods. Tomatoes (and clothes and cars and jewelry and porterhouse steaks) probably fall in that category for most people. Sometimes, however, when a consumer becomes richer, that customer buys less of a good. For example, they might buy a car and stop taking public transportation and might stay in nice hotels instead of youth hostels. The consumption of public transportation and hotels still responds to income or wealth, but in a different direction.

Consumer Tastes

A change in consumer preferences or tastes for tomatoes (for a given level of the consumer's income and tomato prices) will change the amount of tomatoes the consumer wants to purchase. Taste changes can be driven by all sorts of forces. For example, news about the health benefits of eating tomatoes would make many consumers want to eat more of them. News about salmonella found in some tomato crops will make consumers reluctant. For other products, taste changes might arise due to a popular advertising campaign, fads, changes in demographics, and so on.

Prices of Other Goods

Produce vendors at Pike Place Market sell other goods such as onions and peppers that consumers can use to make their salads or pasta sauces. Goods that can be used in place of another good are called **substitutes**. When the price of a substitute good falls, consumers will want to buy more of that substitute and less of the initial good. The lower the prices of onions and peppers relative to the price of tomatoes, the fewer tomatoes consumers will want to buy. We can also think of tomatoes in some other market (say, at another location, like a consumer's neighborhood grocery store) as substitutes for tomatoes at Pike Place Market. If grocery store tomatoes become cheaper, shoppers are going to want to buy fewer tomatoes at Pike Place Market.

substitute
A good that can be used in place of another good.

Vendors at Pike Place Market also sell goods that consumers like to use with tomatoes. Goods that are often purchased and used in combination with a certain good are called **complements**. When the price of a complement falls, consumers will want to buy more of it and also more of the initial good. There are some goods that people like to consume with tomatoes—basil, for instance, or mozzarella cheese. If basil prices fall, consumers are likely to want to buy more basil and with it buy *more* tomatoes as a result.

complement
A good that is often purchased and used in combination with another good.

The prices of substitutes and complements both affect how much of a good consumers want to buy, but they have opposite effects. A price decrease in a good's substitute will cause consumers to want less of the good; a price decrease in a good's complement will cause consumers to want more of the good.

Demand Curves

In economics, "demand" is a catch-all word that captures the many different factors that influence the willingness of consumers to purchase a good. With so many factors influencing demand, it is difficult to wrap our minds around what would happen if all those various factors changed at the same time. We simplify the problem by considering what happens to the amount consumers demand when only a good's price changes, while everything else that determines consumer demand stays the same.

Graphical Representation of the Demand Curve

The result of this simplifying assumption is a **demand curve**, which is the relationship between the quantity of a good that consumers demand and the good's price, holding all other factors constant.[2] Price is on the vertical axis and quantity demanded is on the horizontal axis. **Figure 2.1** depicts a demand curve for tomatoes at the Pike Place Market.

demand curve
The relationship between the quantity of a good that consumers demand and the good's price, holding all other factors constant.

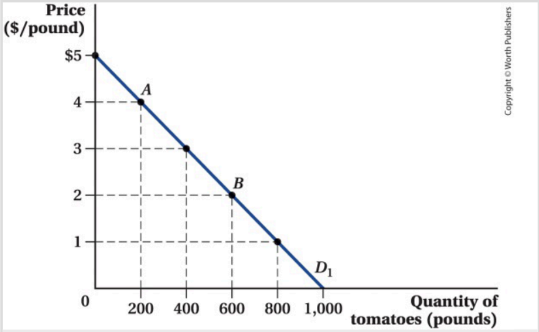


Figure 2.1 Demand for Tomatoes

The demand curve
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for tomatoes at Pike Place Market shows how the quantity of tomatoes that consumers want varies with the price of tomatoes. As the price of tomatoes decreases, consumers demand greater quantities of tomatoes, creating a downward-sloping demand curve. At a price of $5 per pound, consumers demand no tomatoes; at $4, $3, $2, and $1, consumers are willing to purchase 200, 400, 600, and 800 pounds of tomatoes, respectively.

The point about demand curves holding all factors other than price constant is so important that it is worth repeating it again: A demand curve is drawn under the assumption that there is no change in *any* of the other factors—such as consumers' incomes, tastes, or the prices of other goods—that might also affect how much of a good consumers buy at any given price. This means the demand curve in Figure 2.1 embodies the results of the following thought experiment: Show up at Pike Place Market some weekend and observe both the price of tomatoes and the amount consumers buy. Imagine we have magical powers that allow us to go back in time and replace the tags on tomatoes at the market, lowering their price by $1 per pound. Then let the weekend happen all over again—the same weather, the same visitors to the market, the same set of items on display, and so on; the only difference is that tomatoes are $1 per pound cheaper. What's the total amount of tomatoes consumers buy at this new price? Repeating this exercise over and over at different prices gives us a collection of price and quantity combinations that we call the demand curve.

The demand curve in Figure 2.1 exhibits a fundamental characteristic of demand curves: They slope downward.[3] This is another way of saying that, all else equal, the lower the price of a good, the greater the amount of it consumers will buy.

Mathematical Representation of the Demand Curve

We could also represent the demand curve in Figure 2.1 mathematically by the equation

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where Q is the quantity demanded (in pounds) and P is the price (in dollars per pound). This equation implies that every $1 per pound increase in price leads to a 200-pound decline in the quantity of tomatoes demanded. The price at which quantity demanded equals zero, the vertical intercept of the inverse demand curve (here, it's $5), has a special name: the **demand choke price**. It is the price at which no consumer is willing to buy a good.

demand choke price
The price at which quantity demanded is zero; the vertical intercept of the inverse demand curve.

Sometimes economists turn this relationship around. An **inverse demand curve** is a demand curve written in the form of price as a function of quantity demanded. The inverse demand curve for tomatoes at Pike Place Market is
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(We've simply rearranged the demand curve equation to put price in terms of quantity rather than the other way around.) It is sometimes easier to work with inverse demand curves, in part because demand curves are drawn with price on the vertical axis and quantity on the horizontal.

inverse demand curve
A demand curve written in the form of price as a function of quantity demanded.

Shifts in Demand Curves

A given demand curve such as

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in Figure 2.1 illustrates how the quantity demanded of a good changes as its price, *and only its price,* changes. When one of the other (nonprice) factors that affect demand changes, the change affects the quantity of tomatoes consumers want to buy at every price. For example, if there is an outbreak of salmonella poisoning, and public health officials believe that tomatoes may be the source of the outbreak, consumers' tastes will change. They will want fewer tomatoes at any given price than they did before, and the demand curve will shift down and to the left to

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as shown in **Figure 2.2**.[4] Mathematically, the demand

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curve corresponds to

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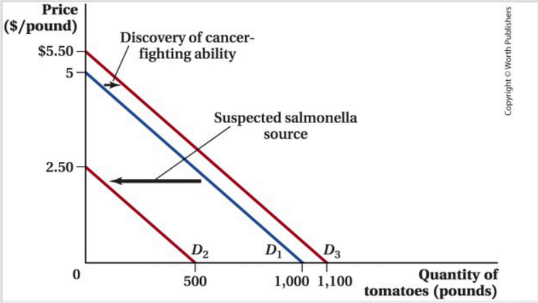

Figure 2.2 Shifts in the Demand Curve

The demand curve

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shifts with a change in any nonprice factor that affects demand. If tomatoes are suspected of being a source of salmonella, consumers will demand fewer tomatoes at any given price and the demand for tomatoes will shift inward, from

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to

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In contrast, if tomatoes are found to have cancer-fighting properties, the demand for tomatoes will shift outward, from

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to

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On the other hand, if scientists discover that tomatoes help prevent cancer, consumers may want to buy more tomatoes at any given price than they did before, and the whole demand curve for tomatoes will shift out to the right from

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to

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(Figure 2.2). Mathematically, the new demand curve

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is described by the equation

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Note that we are shifting the demand curve in the simplest way—sliding it over with the same slope. In real markets, this doesn't need to be true. The new curve can change steepness, too, if demand becomes more or less sensitive to price.

The changes in the quantity demanded at every price that occur when nonprice factors change illustrate an essential distinction:

- **Changes in quantity demanded** are reflected in *movements along a given demand curve* (e.g., the move from point *A* to point *B* in Figure 2.1) and happen when a good's price changes but everything else stays constant.
- **Changes in demand** are reflected in a *shift of a good's entire demand curve* (e.g., the shifts from

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  to

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  and

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in Figure 2.2) and are caused by changes in any of the factors *other than price* that influence demand.

change in quantity demanded
A *movement along the demand curve* that occurs as a result of a change in the good's price.

change in demand
A *shift of the entire demand curve* caused by a change in a determinant of demand other than the good's own price.

We treat prices differently than other factors that influence demand because price is a factor that also directly influences the supply of the good, so it is the critical element tying together supply and demand.

2.3 Supply

We have outlined the demand half of the supply and demand model. What factors influence the other half, meaning the combined amount of a good that all producers in a market are willing to sell?

Factors That Influence Supply

Just as there are many factors that determine demand, there are factors that can determine supply. Let's discuss these again in the context of our Pike Place Market tomatoes example.

Price

Just as it does with demand, price plays an important role in supply decisions. If farmers expect to be able to sell tomatoes at $40 a pound at Pike Place Market, they will bring loads of them. If they expect the price to be only $1 per pound, a much smaller quantity will be made available.

Suppliers' Costs of Production

Suppliers' production costs will change when input prices and production technology change. There are many inputs a supplier must use to produce tomatoes and bring them to market, including land, tomato seeds, harvesting equipment, and fuel needed to ship tomatoes to markets, to name just a few. If the prices of these inputs change, the suppliers' costs will change and will influence the quantity of tomatoes supplied to the market.

Similarly, changes in **production technology**, the processes used to make, distribute, and sell a good (such as tomatoes), will change the costs of production. The more efficient these processes are, the lower the costs to sellers of providing tomatoes for sale. Lower costs will raise sellers' willingness to supply tomatoes at a particular price.

production technology

The processes used to make, distribute, and sell a good.

The Number of Sellers

More farmers bringing tomatoes to Pike Place Market will raise the available supply.

Sellers’ Outside Options

Farmers who are busy selling tomatoes at Pike Place Market aren’t selling some other product or selling tomatoes at some other place. A change in farmers’ prospects for doing business in markets for other goods or in other markets for tomatoes can affect their willingness to supply tomatoes at Pike Place Market. These prospects depend on factors such as the prices of other goods the farmers might be growing and selling, or tomato prices at other places where tomatoes are bought and sold (other than Pike Place Market).

Supply Curves

Just as we introduced demand curves as a way of thinking in a more focused manner about demand, we can do the same for supply. **Supply curves** show the relationship between the quantity supplied of a good and the good’s price, holding all other factors constant. Like demand curves, they capture the idea that factors influencing supply can be divided into two sets: (1) price and (2) everything else.

supply curve
The relationship between the quantity supplied of a good and the good’s price, holding all other factors constant.

Graphical Representation of the Supply Curve

Figure 2.3 depicts a supply curve for tomatoes at Pike Place Market. The vertical axis reflects the price of the good, and the horizontal axis is the quantity supplied. The supply curve in the figure slopes upward: Holding everything else equal, producers are willing to supply more of a good as its price rises.[5] Many firms experience increasing costs of production as their output rises. When this is the case, they need to earn a higher price in the market in order to induce them to produce more output.

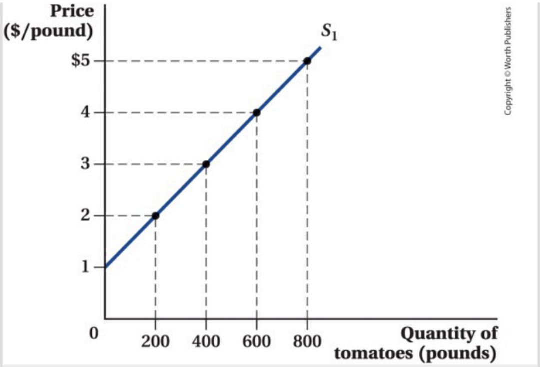

Figure 2.3 Supply of Tomatoes

The supply curve

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for tomatoes at Pike Place Market shows how the quantity of tomatoes supplied varies with the price. As the price of tomatoes increases, producers supply greater quantities of tomatoes, creating an upward-sloping supply curve. At a price of $1 per pound, producers supply no tomatoes; at $2, $3, $4, and $5, respectively, producers supply 200, 400, 600, and 800 pounds of tomatoes.

Mathematical Representation of the Supply Curve

We can write the supply curve in Figure 2.3 mathematically as

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where Q is the quantity supplied (in pounds of tomatoes) and P is the price in dollars per pound. This indicates that holding everything else constant, for every dollar increase in price, the quantity of tomatoes supplied increases by 200 pounds. The **supply choke price** is the price at which no firm is willing to produce a good and quantity supplied is zero; the vertical intercept of the inverse supply curve. In this example, the supply choke price is $1. The **inverse supply curve** is a supply curve written in the form of price as a function of quantity supplied. Here, it’s

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supply choke price
The price at which no firm is willing to produce a good and quantity supplied is zero; the vertical intercept of the inverse supply curve.

inverse supply curve
A supply curve written in the form of price as a function of quantity supplied.

Shifts in the Supply Curve

A given supply curve such as
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in Figure 2.3 illustrates how the quantity supplied of a good changes as its price, and only its price, changes.

When one of the other (nonprice) factors that affect supply changes, the change affects the quantity of tomatoes that suppliers want to sell at every price. For example, if someone invents a machine that can harvest tomatoes faster and at lower cost, producers who wanted to produce 600 pounds of tomatoes at $4 per pound will now be willing to supply 800 pounds of tomatoes at $4. Those who were willing to supply 200 pounds at $2 will now be willing to supply 400 at $2, and so on. Because producers supply more tomatoes at any particular price, the whole supply curve will shift out to the right from
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to
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as shown in **Figure 2.4**. The way we’ve drawn it, that additional quantity is 200 pounds at any price, though there’s nothing that says all supply shifts must exhibit this pattern.[6] Mathematically, the supply curve
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is described by the equation

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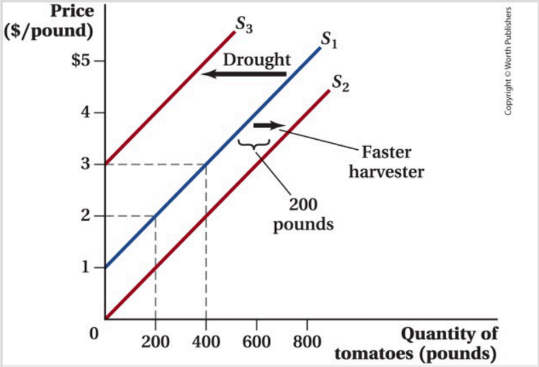

Figure 2.4 Shifts in the Supply Curve

The supply curve
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shifts when any nonprice factor that affects supply changes. If a faster harvesting method is developed, the supply of tomatoes will shift outward, from
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to
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In contrast, if there is a drought, the supply of tomatoes will shift inward, from
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to
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Similarly, if a drought occurs, it will cost producers more to irrigate their fields. They will want to supply fewer tomatoes at any given price than they did before, and the supply curve will shift up and to the left, from
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to
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Mathematically, the supply curve
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corresponds to

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Analogous to demand curves, changes in quantity supplied at every price illustrate a distinction:

- **Changes in quantity supplied** are reflected in movements *along* a given supply curve and happen when a good's price changes but everything else stays constant.
- **Changes in supply** are reflected in shifts of the entire supply curve and are caused by changes in any factors *other than* the good's own price.

change in quantity supplied
A movement *along* the supply curve that occurs as a result of a change in the good's price.

change in supply
A shift of the entire supply curve caused by a change in a determinant of supply other than the good's own price.

Supply curves isolate the effect of prices on supply just as demand curves isolate price effects on demand, and price is a factor that has a direct influence on both supply and demand. Price is the critical element that ties together the two sides of a market. Price's roles in both the supply and demand sides of a market mean that prices can be adjusted freely to make the quantity demanded by consumers equal to the quantity supplied by producers. When this happens, we have a market in which everyone who wants to buy at the current price can do so, and everyone who wants to sell at the current market price can do so as well.

As we see in the next section, we can also use the supply and demand model to predict how changes in nonprice factors affect market outcomes. To get to the point where we *can* do that, however, we need to identify an initial market price and quantity sold. Treating price as special allows us to do just that.

2.4 Market Equilibrium

The true power of the supply and demand model emerges when we combine demand and supply curves. Both relate quantities and prices, so we can draw them on the same graph, with price on the vertical axis and quantity on the horizontal axis. Figure 2.5 overlays the original demand and supply demand curves for tomatoes at Seattle's Pike Place Market. As a reminder, expressed as equations, the demand curve is

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(with an equivalent inverse demand curve

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and the supply curve is

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(with an inverse supply curve of

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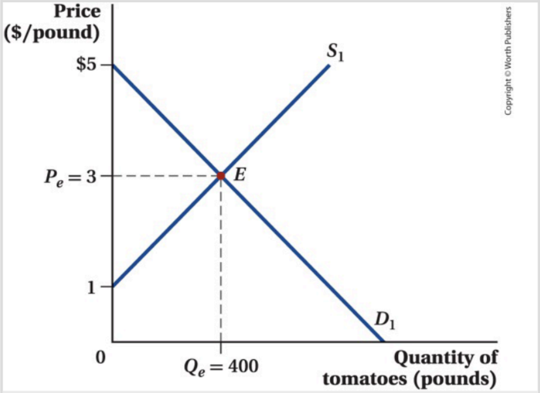

Figure 2.5 Market Equilibrium

The intersection of the supply curve

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and the demand curve

Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml at point *E* represents the market equilibrium. The price and quantity associated with this point are labeled Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml and Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml. The equilibrium price and quantity of tomatoes are $3 per pound and 400 pounds, respectively.

The point where the demand and supply curves cross, where quantity demanded is equal to quantity supplied, is the **market equilibrium**. The equilibrium is labeled as point *E* on Figure 2.5. The **equilibrium price** Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 is the *only* price at which quantity supplied equals quantity demanded.

market equilibrium
The point where the demand and supply curves cross (where quantity demanded equals quantity supplied).

equilibrium price
The only price at which quantity supplied equals quantity demanded.

The Mathematics of Equilibrium

What is the market equilibrium for our Pike Place Market tomatoes example? We can see from Figure 2.5 that the equilibrium price Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an is $3 per pound, and the equilibrium quantity Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an is 400 pounds. But we can also determine these same quantities mathematically by using the equations for the demand and supply curves. Quantity demanded is given by Error parsing MathML: error on line 1 at column 1006: Opening and ending tag mismatch: img line 0 and a (we've added the superscript "D" to quantity just to remind us that this equation is the demand curve), and quantity supplied is Error parsing MathML: error on line 1 at column 1002: Opening and ending tag mismatch: img line 0 and a (again, we've added an identifying superscript). We know that at market equilibrium, quantity demanded equals quantity supplied; that is,

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Using the equations above, we have

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At a price *P* of $3 per pound, quantity demanded Error parsing MathML: error on line 1 at column 707: Opening and ending tag mismatch: img line 0 and an equals quantity supplied Error parsing MathML: error on line 1 at column 707: Opening and ending tag mismatch: img line 0 and an so the equilibrium price Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an is $3, as we observe in Figure 2.5. To find the equilibrium quantity Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an we plug this value of Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an back into the equation for *either* the demand or supply curve, because both quantity demanded and quantity supplied will be the same at the equilibrium price:

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We just solved for the equilibrium price and quantity by using the fact that the quantity demanded equals the quantity supplied in equilibrium, and substituting the demand and supply curve equations into this equality. We could have obtained the same answer by instead using the fact that the price given by the *inverse* demand and supply curves is the same at the market equilibrium quantity. That is,

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Solving this equation gives Error parsing MathML: error on line 1 at column 817: Opening and ending tag mismatch: img line 0 and an pounds, just as before. Plugging Error parsing MathML: error on line 1 at column 817: Opening and ending tag mismatch: img line 0 and an back into either the inverse demand or supply equation indicates that the market price Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an is $3 per pound, as expected.

Why Markets Move toward Equilibrium

When a market is in equilibrium, the quantity demanded by consumers and the quantity supplied by producers are equal at the market price. To see why equilibrium is a stable situation, think about what happens when price is not in equilibrium. If the current price is higher than the equilibrium price, there will be excess supply. If the price is lower, there will be excess demand.

Excess Supply

With a price higher than the equilibrium price, call it
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instead of
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as shown in **Figure 2.6a**, the quantity supplied,
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is greater than the quantity demanded,
Error parsing MathML: error on line 1 at column 900: Opening and ending tag mismatch: img line 0 and an
Producers come out of the woodwork wanting to sell at this high price, but not all producers can find willing buyers at that price. The excess quantity for sale equals
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the horizontal distance between the demand and supply curves at
Error parsing MathML: error on line 1 at column 817: Opening and ending tag mismatch: img line 0 and an
To eliminate this excess supply, producers need to attract more buyers, and to do this, producers must lower their prices. As price falls, quantity demanded rises and quantity supplied falls until the market reaches equilibrium at point *E*.

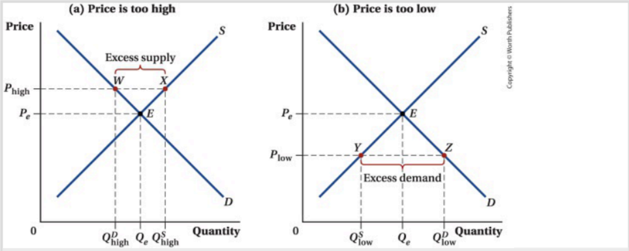

Figure 2.6 Why
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(a) At the price
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above the equilibrium price
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producers supply the quantity
Error parsing MathML: error on line 1 at column 900: Opening and ending tag mismatch: img line 0 and annotation-xml,
while consumers demand only
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This results in an excess supply of the good, as represented by the distance between points *W* and *X*. Over time, price will fall and the market will move toward equilibrium at point *E*.

(b) At the price
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below the equilibrium price
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producers supply the quantity
Error parsing MathML: error on line 1 at column 897: Opening and ending tag mismatch: img line 0 and annotation-xml,
while consumers demand
Error parsing MathML: error on line 1 at column 897: Opening and ending tag mismatch: img line 0 and annotation-xml.
This results in an excess demand for the good, as represented by the distance between points *Y* and *Z*. Over time, price will rise and the market will move toward equilibrium at point *E*.

A+ make the grade

Does quantity supplied equal quantity demanded in equilibrium?

Solving for the market equilibrium as we just did is one of the most common exam questions in intermediate microeconomics classes. The basic idea is always the same: Take the equations for the demand curve and the supply curve, solve for the equilibrium price, and then plug that equilibrium price back into either the supply curve or the demand curve (it does not matter which) to determine the equilibrium quantity. The solution is straightforward, but it is easy to make math errors under the time pressure of an exam, especially if the demand and supply curves take on more complicated forms than the basic examples we deal with here.

A simple trick will ensure that you obtain the right answer, and applying it requires only a few seconds more. Take the equilibrium price that you get and plug it into *both* the demand and supply curves. If you don't arrive at the same answer when you substitute the equilibrium price into the supply and demand equations, you will know immediately that you made a math error along the way because the quantity demanded must equal the quantity supplied in equilibrium.

Excess Demand

The opposite situation exists in Figure 2.6b. At price

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consumers demand a lot of the good when it's that cheap,

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but that amount is more than producers are willing to supply,

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To eliminate this excess demand, buyers who cannot find the good available for sale will bid up the price and enterprising producers will be more than willing to raise their prices. As price rises, quantity demanded falls and quantity supplied rises until the market reaches equilibrium at point *E*.[7]

Adjusting to Equilibrium

In the real world, equilibrium is a bit mysterious. In our stylized model, we're acting as if all the producers and consumers gather in one spot and report to a sort of auctioneer how much they want to produce or consume at each price. The auctioneer combines all this information, computes and announces the market-clearing price, and only then do all the sellers and buyers make their deals at the announced market-clearing price. But few markets work this way in the real world. Real markets must rely on what the great eighteenth-century Scottish economist Adam Smith called the "invisible hand." Producers independently decide how much to produce of their products given the price at which they expect to be able to sell them, and consumers show up at stores, gas stations, or websites to buy the good. Sometimes producers might supply too much or too little in the short run, but through the market, these mistakes eventually correct themselves. Economists typically assume that the market reaches equilibrium one way or another, without being too specific about the process.

figure it out 2.1

Go online for interactive, step-by-step help in solving the following problem.

Suppose that the demand and supply curves for a monthly cell phone plan with unlimited data can be represented by

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The current price of these plans in the market is $40 per month. Is this market in equilibrium? Would you expect the price to rise or fall? If so, by how much? Explain.

Solution:

There are two ways to solve the first question about whether the price will rise or fall. The first is to calculate the quantity demanded and quantity supplied at the current market price of $40 to see how they compare:

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Because quantity demanded is greater than quantity supplied, we can tell that there is excess demand (a shortage) in the market. Many people are trying to purchase unlimited data plans, but they are hard to find because few suppliers want to sell at that price. Prices will rise to equalize quantity supplied and quantity demanded, moving the market to equilibrium.

Alternatively, we could start by solving for the market equilibrium price:

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The current market price, $40, is below the market equilibrium price of $50. (This is why there is excess demand in the market.) Therefore, we would expect the price to rise by $10. When the market reaches equilibrium at a price of $50, all buyers can find sellers and all sellers can find buyers. The price will then remain at $50 unless the market changes and the demand curve or supply curve shifts.

The Effects of Demand Shifts

As we have learned, demand and supply curves hold constant everything else besides price that might affect quantities demanded and supplied. Therefore, the market equilibrium depicted in Figure 2.5 will hold only as long as none of these other factors change. If any other factor changes, there will be a new market equilibrium because either the demand or supply curve or both curves will have shifted.

Suppose the demand for tomatoes falls when, as in our previous example, a news story reports that tomatoes are suspected of being the source of a salmonella outbreak. The resulting change in consumer tastes causes the demand curve to shift in (i.e., to the left), as **Figure 2.7** shows, from

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to

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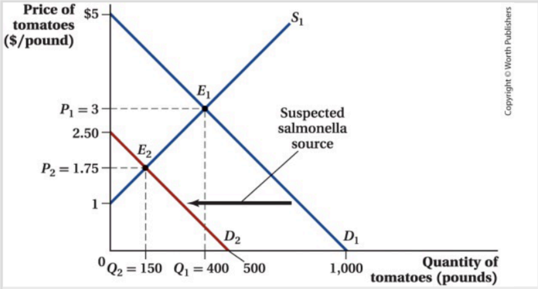

Figure 2.7 Effects of a Fall in the Demand for Tomatoes

After a salmonella outbreak, the demand for tomatoes decreases, causing a leftward shift of the demand curve from

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to

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This fall in demand results in a new equilibrium point

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which is lower than the initial equilibrium point

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The equilibrium quantity falls from

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(400 pounds) to

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(150 pounds), and the equilibrium price falls from

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($3) to

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($1.75).

How does the market equilibrium change after this demand shift? The equilibrium price and quantity both fall. The equilibrium quantity falls from

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to

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and the equilibrium price drops from

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to

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The reason for these movements is that if prices stayed at

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after the fall in demand, tomato farmers would be supplying a much greater quantity than consumers were demanding. The market price must fall to get farmers to rein in their quantity supplied until it matches the new, lower level of demand.

We can solve for the new equilibrium price and quantity using the same approach we applied earlier, but using the equation for the new demand curve

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which is

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(The supply curve stays the same.)

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So, the new equilibrium price is $1.75 per pound, compared to $3 per pound from before the demand shift. Plugging this into the new demand curve (or the supply curve) gives the new equilibrium quantity:

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The new equilibrium quantity is 150 pounds, less than half of what it was before the demand shift.

We could have just as easily worked through an example in which demand increases and the demand curve shifts out. Perhaps incomes rise or substitute produce items become more expensive. In the face of a stable supply curve, this increase in demand would shift the curve up to the right and cause both the equilibrium price and quantity to rise. At the previous market price, the new quantity demanded would be greater than sellers' willingness to supply. The price would have to rise, causing a movement along the supply curve until the quantities supplied and demanded are equal.

Shifts in Curves versus Movement along a Curve

This analysis highlights the importance of distinguishing between shifts in a demand or supply curve and movements along those curves. This distinction can sometimes seem confusing, but understanding it is critical. We saw in Figure 2.7 what happens to a market when there is a change in consumers' tastes that makes them view a product more negatively. That change in tastes made consumers want to buy less of the product at any given price—that is, caused an inward *shift* in the demand curve. Remember, anything that changes how much consumers want to buy of a good at any particular price must shift the demand curve. At the same time, this change in tastes has no effect on how much producers wish to sell at any given price. It doesn't affect their costs of producing or their outside options. So, supply does not change, and the supply curve doesn't shift. However, the *quantity supplied* does change. It falls in response to the reduced demand. This change in quantity supplied is a movement *along* the supply curve. The only reason that the quantity supplied falls in this example is because the shift in the demand curve has made the equilibrium price lower, and at a lower price, suppliers produce less of the good. Therefore, a *shift* in the demand curve causes a movement *along* the supply curve to the new equilibrium.

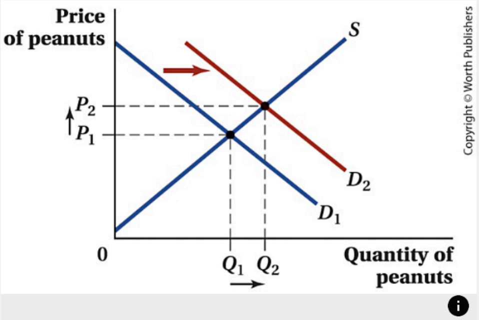
figure it out 2.2

Draw a supply and demand diagram of the market for peanuts.

a. Suppose that someone develops a cure for peanut allergies, so people who formerly had to avoid peanut foods can now eat them. What will happen to the equilibrium price and quantity of peanuts?
b. Does this change reflect a change in demand or a change in quantity demanded?

Solution:

a. Peanuts are a substitute for other foods. If peanut allergies are cured so that more people can eat peanuts than before, the demand for peanuts will rise, and the demand curve will shift out to the right. As the figure shows, this shift will result in a higher equilibrium price and quantity of peanuts purchased.
b. Because the allergy cure changes the appeal of peanuts at any given price, this is a change in the demand for peanuts.



The Effects of Supply Shifts

Now let's think about what happens when the supply curve shifts, but the demand curve does not. Figure 2.8 shows the case in which the supply of tomatoes rises, shifting the supply curve out from

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to

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This shift implies that, at any given price, farmers are willing to sell a larger quantity of tomatoes than before. Such a shift would result from a reduction in farmers' input costs—for example, if seed prices fell. The logic of why a cost reduction increases quantity supplied at any given price is straightforward: If the farmers can make an average profit of, say, $1 per pound when the price is $3 per pound, then a $1 decrease in cost (which increases their profit) will lead farmers to offer more for sale. Note, however, that this cost change has no direct impact on the demand curve. Holding price fixed, consumers are no more or less willing to buy tomatoes than they were before.

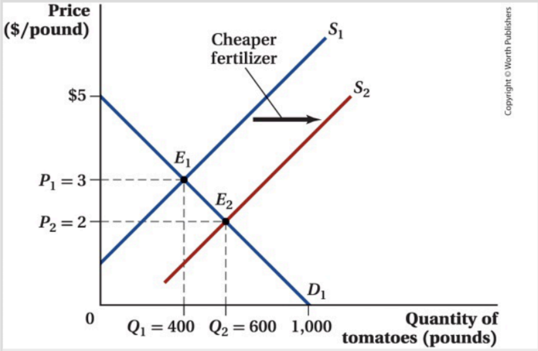

Figure 2.8 Effects of an Increase in the Supply of Tomatoes

With cheaper fertilizer, farmers supply more tomatoes at every given price and the supply curve shifts outward from

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to

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The equilibrium quantity increases from

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(400 pounds) at

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to

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(600 pounds) at

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while the equilibrium price falls from

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to

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The supply curve has shifted from its original position

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(given by the equation

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to

Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an

(given by the equation

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If the price stayed at the original equilibrium price

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after the supply shift, the amount of tomatoes that sellers would be willing to supply would exceed consumers' quantity demanded. Therefore, the equilibrium price must fall, as seen in the figure. This drop in price causes an increase in quantity demanded along the demand curve. The price drops until the quantity demanded once again equals the quantity supplied. The new equilibrium price is

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and the new equilibrium quantity is

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We can solve for the new equilibrium price and quantity using the equations for the original demand curve and the new supply curve:

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The cost drop and the resulting increase in supply lead to a fall in the equilibrium price from $3 to $2 per pound. This is intuitive: Lower farmers' costs end up being reflected in lower market prices. We can plug this price into either the demand or new supply equation to find the new equilibrium quantity:

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The equilibrium quantity of tomatoes increases from 400 to 600 pounds in response to the increase in supply and the subsequent fall in the equilibrium price.

Again, we could go through the same steps for a decrease in supply. The supply curve would shift up to the left. This decline in supply would increase the equilibrium price and decrease the equilibrium quantity.

FREAKONOMICS

How Uber Took the Taxi Industry by Storm

Every time a snowstorm hits New York City, people get a lesson in market equilibrium. Traffic becomes snarled. People's tempers flare. And taxis are virtually impossible to find. Yet riders with ride-share companies like Uber can summon one with almost no wait time.

You would think such commuters might be happy that Uber can deliver them home even as the massive New York taxi system fails. But they usually aren't, because in such circumstances Uber prices go up—a lot.

Snowstorms have historically created a supply and demand nightmare for taxi drivers. The city regulates the rate and fees taxis may charge, which means that drivers are unable to adjust their prices. To make money, drivers must complete many trips. When road conditions are bad, the risk of an accident goes up and traffic can slow to a crawl, but taxi drivers cannot charge more to drive in those conditions. So when storms hit, many taxi drivers decide that it isn't worth it to remain on the streets, and head back to the garage. When it snows, demand is high and supply is low. The price needs to rise, but for taxi drivers, it can't.

Uber, on the other hand, relies on software that can adjust prices to match supply and demand. Everyone that wants to ride at the market price can do so because two events occur: Some consumers are not willing to pay the higher price, and they drop out of the market. And some Uber drivers who would not have wanted to drive at regular prices decide it's worth it to pick up passengers at the higher fare. By choosing a high enough price, Uber can equilibrate supply and demand—even in extreme circumstances like a snowstorm. The problem for Uber, however, is that the equilibrium price sometimes turns out to be very high. Suddenly, Uber's Twitter feed blows up as customers vent their frustration over the higher "surge" prices.[*]

Marc Meyerbroeker/Caro/Newscom

Good luck finding a cab when the snow starts falling in New York City.

These passengers seem to forget a basic principle of equilibrium. As one of the drivers responded to the mounting complaints:

> I hope everyone realizes that, as a Driver, if there wasn't any surge pricing, I'd just stay home in a snow storm. There would be no drivers and then everyone would be complaining about how they waited 30 mins for a car to pick them up to take them 6 blocks.

If Uber doesn't raise prices, there wouldn't be enough Ubers, just like there aren't enough taxis.

But the cold logic of economic equilibrium can make for some serious black eyes in terms of public relations. Uber's automated surge-pricing algorithm raised prices dramatically when demand escalated following a bomb threat in New York City and violent mass attacks in London and Sydney. If you wanted to get away from the threat of danger, it cost you four times the regular price.

Uber has learned from the bad publicity. While it still uses surge pricing, it imposes caps so that prices do not soar too high for consumers in critical situations. And to ensure that drivers keep driving under such circumstances, Uber continues to pay drivers the high rates they'd like to charge consumers. In other words, Uber takes a loss on rides in extreme-weather events, because its executives have determined that the long-run benefits of this policy outweigh the short-run costs.

That's a different kind of equilibrium.

figure it out 2.3

Go online for interactive, step-by-step help in solving the following problem.

Suppose that the supply of orange juice is represented by Error parsing MathML: error on line 1 at column 879: Opening and ending tag mismatch: img line 0 and annotation-xml, where *Q* is measured in pints and *P* is measured in cents per pint.

a. If the demand for orange juice is Error parsing MathML: error on line 1 at column 1003: Opening and ending tag mismatch: img line 0 and annotation-xml, what are the current equilibrium price and quantity?
b. Suppose that a severe frost in Florida raises the price of oranges and thus the cost of producing orange juice. In response to the increase in cost, producers reduce the quantity of orange juice supplied by 400 pints at every price. What is the new equation for the supply of orange juice?
c. After the frost, what will the equilibrium price and quantity of orange juice be?

Solution:

a. To solve for the equilibrium price, we need to equate the quantity demanded and quantity supplied:

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   To solve for the equilibrium quantity, we want to substitute the equilibrium price into either the demand curve or the supply curve (or both!):

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b. If the quantity supplied of orange juice falls by 400 pints at every price, then the supply curve is shifting left (in a parallel fashion) by a quantity of 400 at each price:

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   The new supply curve can be represented by Error parsing MathML: error on line 1 at column 1070: Opening and ending tag mismatch: img line 0 and annotation-xml.

c. To solve for the new equilibrium, we would set Error parsing MathML: error on line 1 at column 1030: Opening and ending tag mismatch: img line 0 and annotation-xml:

   Error parsing MathML: error on line 81 at column 40: Opening and ending tag mismatch: img line 0 and annotation-xml

   Solving for equilibrium quantity can be done by substituting the equilibrium price into either the demand or supply equation:

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   As we would expect (see Table 2.2), the equilibrium price rises and the equilibrium quantity falls.

Summary of Effects

Table 2.2 summarizes the changes in equilibrium price and quantity that result when either the demand or supply curve shifts while the other curve remains in the same position. When the demand curve shifts, price and quantity move in the same direction. An increase in demand leads consumers to want to purchase more of the good than producers are willing to supply at the old equilibrium price. This will tend to drive up prices, which in turn induces producers to supply more of the good. The producers' response is captured by movement along the supply curve.

Table 2.2 Effect of Shifts in Demand and Supply Curves in Isolation

		Impact on Equilibrium	
Curve that Shifts	**Direction of Shift**	**Price**	**Quantity**
Demand Curve	Out (increase in *D*)	↑	↑
	In (decrease in *D*)	↓	↓
Supply Curve	Out (increase in *S*)	↓	↑
	In (decrease in *S*)	↑	↓

When the supply curve shifts, price and quantity move in opposite directions. If supply increases, the supply curve shifts out, and producers want to sell more of the good at the old equilibrium price than consumers wish to buy. This will force prices down, giving consumers an incentive to buy more of the good. Similarly, if supply shifts in, the equilibrium price has to rise to reduce the quantity demanded. These movements along the demand curve involve price and quantity changes in opposite directions because demand curves are downward-sloping.

Application: Supply Shifts and the Classic Video Game Crash

People love video games. Video game sales topped $60 billion in the United States in 2021.

That's more than, for instance, the total amount that Americans spent at jewelry stores ($50 billion) or all California residents and businesses spent on gasoline ($55 billion).[8]

Seeing these numbers, you'd never know that in the industry's early days, there was a point when many people declared video games a passing fad and a business in which it would be impossible to make a profit. Why did people say this? The problem wasn't demand. Early video games, from *Pong* to *Space Invaders* and consoles like the Atari 2600, were a huge hit and cultural touchstones. The problem was supply—way too much of it. In 1983 a set of factors combined to lead to a massive supply shift for the industry in North America that ended up crippling it for years.

Two primary factors led to the supply shift. Home video consoles, led by the Atari 2600 but also including popular machines from Mattel and Coleco, had taken off in the early 1980s. At this early point in the industry, console producers hadn't yet learned the best way to handle licensing arrangements with third-party game producers. As a result, just about anyone who wanted to could write a game title for a console. And just about everyone did. Even the pet food company Purina got into the game business, producing *Chase the Chuck Wagon* (which involved a dog chasing a chuck wagon through a maze) to promote its dog food brand. In essence, there was a gold rush: Many producers, each hoping to capture part of the fast-growing market, entered at the same time. This led to a much larger total supply of games (which were then sold on plastic cartridges) than any producer expected individually beforehand. The same phenomenon occurred in console production as well. Several companies made clones of Atari's market-leading console, and others produced their own machines and lines of games.

ATARI
E.T.
CAT

Juan Carlos Llorca/AP Photo

The discovery of a long-buried *E.T. the Extra-Terrestrial* Atari game after an excavation at a New Mexico landfill.

The leading console makers didn't help themselves with their own game-production decisions either. The most infamous failures were Atari's self-produced games *Pac-Man* and *E.T. the Extra-Terrestrial.* Atari management expected unprecedented sales for both, due to the extreme popularity of the arcade version of the former and the movie tied to the latter. In fact, Atari produced 12 million copies of *Pac-Man* even though there were only 10 million consoles in existence at the time, presuming that not only would just about every owner of a console buy the game, but also millions of others would purchase a console just to play the game. Both were rushed through production to take advantage of the holiday shopping seasons. The games were full of glitches, and quantity supplied well exceeded quantity demanded, even at the depressed prices in the market.

The sudden rush of producers to put product on the market created an outward shift in the supply curve—producers' behavior made clear that they were willing to produce more at any given price in early 1983 than they were just a couple years earlier, in early 1981. And while the demand for home video games had been trending upward as the technology diffused through households, the rush to produce new titles and consoles probably didn't have much of an effect on the demand curve. (In fact, the poor quality of the new games—which were often produced quickly and with little testing—may have even shifted the demand curve inward.) It's reasonable to assume, then, that the demand curve was unmoved by the producer gold rush. The supply and demand model predicts the consequences of this supply shift on the market. A shift out in the supply curve in the face of constant demand will lead to an increase in quantity and a drop in prices, as shown in **Figure 2.9**. (These days, video game companies take more care in rolling out new games.)

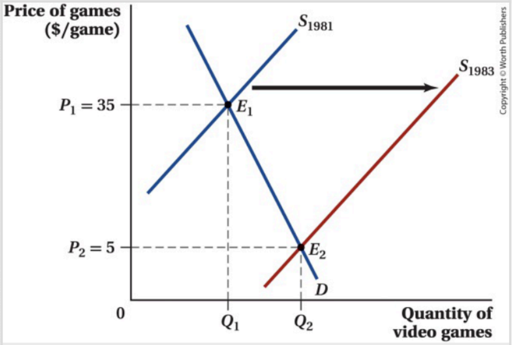

Figure 2.9 Effects of an Increase in the Supply of Video Games

In 1983 a sudden increase in the number of video game producers shifted the supply curve from
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to
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At the equilibrium, the price of video games dropped from
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to

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while the quantity increased from
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to
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That's exactly what happened in the video game industry. Price changes, in particular, were precipitous. Games that had been selling a year earlier at list prices of $35–$50 were being sold for $5 or even $1. Console prices fell by double-digit percentages as well. With games going at these rates, quantities increased somewhat, but nowhere near enough to make them profitable for their producers. Dozens of firms—console and games makers alike—went out of business. Atari, which until then had been a cash machine, ended up secretly burying hundreds of thousands of unshipped *E.T.* cartridges in a landfill in the New Mexico desert and was sold by its parent Warner Communications. It never recovered. The carnage was so total that some retailers, figuring the market was hopeless, refused to stock games anymore. It essentially wiped out producers from the market for three to four years, an eternity in this fast-moving industry where technological races are seemingly never-ending. The dire situation finally turned around when a company known as Nintendo managed to convince retailers that its all-new 8-bit Nintendo Entertainment System would revitalize the moribund industry.

So, if you are wondering why, even today, Nintendo takes its time releasing games on the Switch, now you know the answer. ■

figure it out 2.4

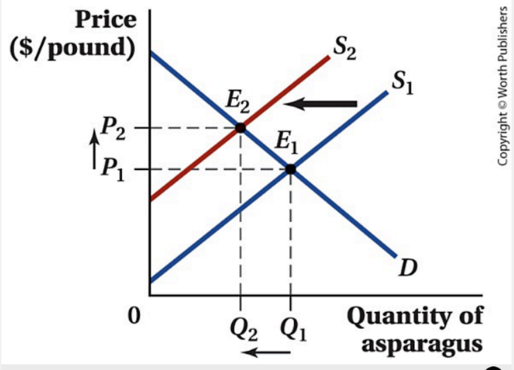
Last month, you noticed the price of asparagus rising, and you also noted that there was less asparagus being sold than in the prior month. What inferences can you draw about the behavior of the supply and demand for asparagus?

Solution:

We need to work backward to determine what could have happened to either supply or demand to lead to the change described in this question. Let's start with the change in price. The equilibrium price of asparagus is *rising.* This must mean one of two things: Either the demand for asparagus rose or the supply of asparagus fell. (If you have trouble seeing this, sketch a couple of quick figures.)

We also know that the equilibrium quantity of asparagus fell. A drop in the equilibrium quantity can only have two causes: either a decrease in the demand for asparagus or a fall in the supply of asparagus. (Again, you may want to draw these scenarios to understand such results.)

Which shift leads to both a rise in equilibrium price and a fall in equilibrium quantity? It must be a decrease in the supply of asparagus, as shown in the figure.



make the grade

Did the curve shift, or was it just a movement along the curve?

A common type of exam question on demand and supply will involve one or more "shocks" to a market—changes in factors that influence demand or supply. Your job will be to sort out how those shocks affect demand and supply, and by extension, the equilibrium price and quantity in the market. Generally, the trickiest part of questions like these is figuring out whether changes in price and quantity are the result of moving along a given demand or supply curve, or whether the curves are shifting.

If you follow a few simple steps, this type of question need not be too difficult.

1. **Figure out what the shock is in any particular problem.** It is the change that causes a shift in either the supply curve, the demand curve, or both. There is a nearly infinite variety of shocks. A new invention might make it cheaper to manufacture a good, a different good that consumers like better might be introduced, or inclement weather might damage or kill off a large portion of a certain crop. And as we've all experienced in the past few years, a pandemic could drastically change consumers' buying habits.

   Importantly, though, a change in either the price or the quantity of the good *in the market being studied* cannot be the shock. The changes in price and quantity in this market are the *result* of the shock, not the shock itself. Be careful, however: Changes in prices or quantities in some *other* market can serve as a shock to this market. If the price of chunky peanut butter falls, for example, that could be a shock to the market for grape jelly or the market for creamy peanut butter.

2. **Determine whether the shock shifts the demand or supply curve.**
   a. To figure out whether a shock shifts the demand curve and how the shock shifts it, ask yourself the following question: If the price of this good didn't change, would consumers want to buy more, less, or the same amount of the good after the shock? If consumers want more of the good at the same price after the shock, then the shock increases the quantity demanded at every price and shifts the demand curve out (to the right). If consumers want less of the good at the same price after the shock, then the shock decreases demand and the demand curve shifts in. If consumers want the same amount of the good at the same price, then the demand curve doesn't move at all, and it's probably a supply shock.

      Let's go back to the grape jelly example. Our shock was a decline in the price of peanut butter. Do consumers want more or less grape jelly (holding the price constant) when peanut butter gets cheaper? The answer to this question is probably "more." Cheap peanut butter means consumers will buy more peanut butter, and because people tend to eat peanut butter and jelly together, consumers will probably want more jelly even if the price of jelly stays the same. Therefore, the decline in peanut butter's price shifts the demand for grape jelly out.

   b. To figure out whether a shock shifts the supply curve and how it shifts it, ask yourself the following question: If the price of this good didn't change, would suppliers want to produce more, less, or the same amount of the good after the shock? In the jelly example, a change in the price of peanut butter doesn't affect the costs of making jelly—it's not an input into jelly production. So, it's not a supply shock. An increase in the price of grapes, however, would be a supply shock in the market for grape jelly.
3. **Draw the market's demand and supply curves before and after the shocks.** In the jelly example, we would draw the original demand and supply curves, and then add the new demand curve (to the right of the initial demand curve) that results from the increase in the demand for jelly because of lower peanut butter prices. From this, it's easy to execute the final step, interpreting what impact the shock has on equilibrium price and quantity. For grape jelly, the increase in demand will result in a higher equilibrium price and quantity for jelly because the demand shift creates movement up and to the right along the jelly supply curve.

Practice following this approach; before long, manipulating demand and supply curves will become second nature.

What Determines the Size of Price and Quantity Changes?

Thus far, the analysis in the chapter (summarized in Table 2.2) tells us about the *direction* in which equilibrium price and quantity move when demand and supply curves shift. But we don't know the size of these changes. In this section, we discuss the factors that determine how large the price and quantity changes are.

Size of the Shift

One obvious and direct influence on the sizes of the equilibrium price and quantity changes is the size of the demand or supply curve shift itself. The larger the shift, the larger the change in equilibrium price or quantity.

Slopes of the Curves

Even for a fixed-size demand or supply curve shift, the magnitudes of the resulting equilibrium price and quantity changes can vary. Specifically, the *relative* sizes of the price and quantity changes depend on the steepness of the demand and supply curves (**Figure 2.10**). If the demand curve shifts, then the slope of the supply curve determines whether the shift leads to a relatively large equilibrium price change and a relatively small equilibrium quantity change, or vice versa. If the supply curve shifts, it's the slope of the demand curve that matters.

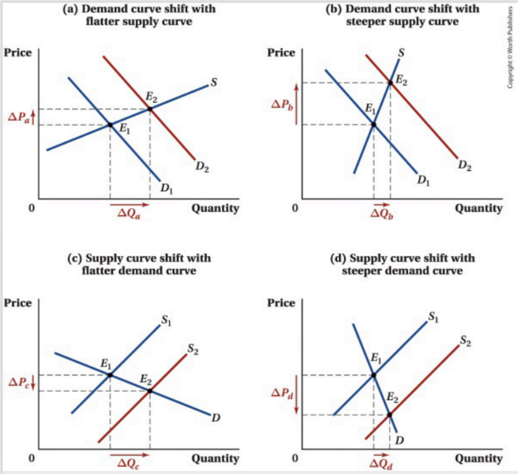


Figure 2.10 Size of Equilibrium Price and Quantity Changes, and the Slopes of the Demand and Supply Curves

Panels a and b show the same shift in the demand curve, from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml. In panel a, the supply curve is relatively flat, while in panel b, it's relatively steep. When the demand curve shifts, if the supply curve is flat (panel a), the change in the equilibrium quantity Error parsing MathML: error on line 1 at column 954: Opening and ending tag mismatch: img line 0 and annotation-xml will be relatively large but the change in price Error parsing MathML: error on line 1 at column 954: Opening and ending tag mismatch: img line 0 and annotation-xml will be small. When the supply curve is steep (panel b), the price change Error parsing MathML: error on line 1 at column 954: Opening and ending tag mismatch: img line 0 and annotation-xml is large and the quantity change Error parsing MathML: error on line 1 at column 954: Opening and ending tag mismatch: img line 0 and annotation-xml is small. The same results hold for shifts in the supply curve. Panels c and d show the same supply curve shift, from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml. When the demand curve is relatively flat (panel c), a shift in supply from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml will result in a relatively small decrease in equilibrium price Error parsing MathML: error on line 1 at column 775: Opening and ending tag mismatch: img line 0 and annotation-xml and a relatively large increase in equilibrium quantity Error parsing MathML: error on line 1 at column 775: Opening and ending tag mismatch: img line 0 and annotation-xml. With a relatively steep demand curve (panel d), a shift in supply from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml will result in a relatively large decrease in equilibrium price Error parsing MathML: error on line 1 at column 775: Opening and ending tag mismatch: img line 0 and annotation-xml and a relatively small increase in equilibrium quantity Error parsing MathML: error on line 1 at column 775: Opening and ending tag mismatch: img line 0 and annotation-xml.

This analysis raises an obvious question: What affects the slope of demand and supply curves? We discuss the economic forces that determine the steepness or flatness of demand and supply curves next.

Changes in Market Equilibrium When Both Curves Shift

Sometimes, we are faced with situations in which demand and supply curves move simultaneously. For example, Figure 2.11 combines two shifts: decreases (inward shifts) in both supply and demand. Let's return to the tomato market at Pike Place Market and suppose that a big increase in oil prices occurs. This increase drives up the cost of production because harvesting and distribution costs rise for sellers. Increased oil prices also decrease the demand for tomatoes, because driving to the market becomes more expensive for consumers and so there are fewer people buying at any given price.

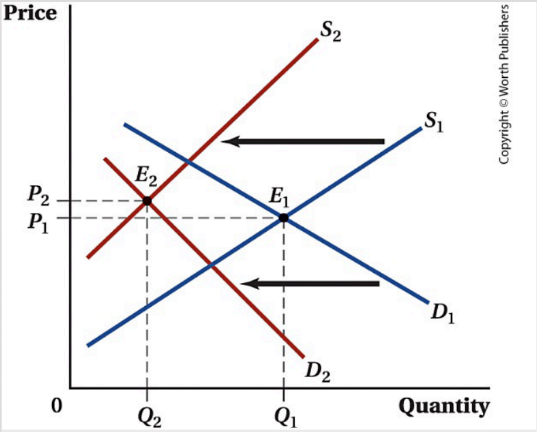


Figure 2.11 Example of a Simultaneous Shift in Demand and Supply

The original equilibrium occurred at the intersection of
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and
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point
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An inward shift of both the demand and supply curves results in a new equilibrium point
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at the intersection of
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and
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At
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the price has increased slightly from
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to
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and the quantity has decreased substantially from
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to
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In this particular case, the simultaneous inward shifts in supply and demand have led to a substantial reduction in the equilibrium quantity and a slight increase in price. The reduction in quantity should be intuitive. The inward shift in the demand curve means that consumers want to buy less at any given price. The inward shift in the supply curve means that at any given price, producers want to supply less. Because both producers and consumers want less quantity, equilibrium quantity falls unambiguously, from
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to
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The effect on equilibrium price is not as clear, however. An inward shift in demand with a fixed supply curve will tend to reduce prices, but an inward shift in supply with a fixed demand curve will tend to raise prices. Because both curves are moving simultaneously, it is unclear which effect will dominate, and therefore whether equilibrium price rises or falls. We have drawn the curves in Figure 2.11 so that the equilibrium price rises slightly, from
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to
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But had the demand and supply curves shifted by different amounts (or had they been flatter or steeper), the dual inward shift might have led to a decrease in the equilibrium price, or no change in the price at all.

As a general rule, when both curves shift at the same time, we will know with certainty the direction of change of either the equilibrium price or quantity, but never both. This result can be seen by closer inspection of Table 2.2. If the demand and supply curve shifts are both pushing price in the same direction, which would be the case if (1) the demand curve shifted out and the supply curve shifted in or (2) the demand curve shifted in and the supply curve shifted out, then the same shifts 1 or 2 will push quantities in opposite directions. Likewise, if the shifts in both curves serve to move quantity in the same direction—either (3) demand and supply both shift out or (4) demand and supply both shift in—the shifts 3 and 4 have opposing effects on equilibrium prices. The example we just looked at in Figure 2.11 involved a case of shift 4.

This ambiguity is also apparent in the example given in **Figure 2.12**. The directions of the shifts in the demand and supply curves are the same in each panel of the figure: Supply shifts inward from

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to

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and demand shifts outward from

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to

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Both these shifts will lead to higher prices, and this is reflected in the change in the equilibrium (from point

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to

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But, whether the equilibrium quantity rises, falls, or stays the same depends on the relative size of the shifts and the slopes of the curves. The figure's three panels show examples of each possible case. When examining a situation in which both supply and demand shift, you might find it helpful to draw each shift in isolation first, note the changes in equilibrium quantity and price implied by each shift, and then combine these pieces of information to obtain your answer.

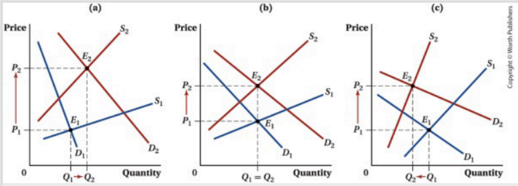

Figure 2.12 When Both Curves Shift, the Direction of Either Price or Quantity Will Be Ambiguous

(a) In all three panels, there is an outward shift in demand (Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml) and an inward shift in supply (Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml). Here, both equilibrium price (Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml) and quantity (Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml) increase as a result.

(b) Equilibrium price increases from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml, while equilibrium quantity stays the same Error parsing MathML: error on line 1 at column 1189: Opening and ending tag mismatch: img line 0 and annotation-xml.

(c) Equilibrium price increases from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml, while equilibrium quantity decreases from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml.

2.5 Elasticity

Mathematically, the slopes of demand and supply curves relate changes in price to changes in quantity demanded or quantity supplied. Steeper curves mean that price changes are correlated with relatively small quantity changes. When demand curves are steep, this implies that consumers are not very price-sensitive and won't significantly alter their quantity demanded in response to price changes. Similarly, steep supply curves mean that producers' quantities supplied are not particularly sensitive to price changes. Flatter demand or supply curves, on the other hand, imply that price changes are associated with large quantity changes. Markets with flat demand curves have consumers whose quantities demanded change quite a bit as price varies. Markets with flat supply curves will see big movements in quantity supplied as prices change.

The concept of elasticity expresses the responsiveness of one value to changes in another (and here specifically, the responsiveness of quantities to prices). An **elasticity** is the ratio of the percentage change in one value to the percentage change in another. So, for example, when we talk about the sensitivity of consumers' quantity demanded to price, we refer to the **price elasticity of demand**: the percentage change in quantity demanded resulting from a given percentage change in price.

elasticity
The ratio of the percentage change in one value to the percentage change in another.

price elasticity of demand
The percentage change in quantity demanded resulting from a given percentage change in price.

Slope and Elasticity Are Not the Same

You might be thinking that the price elasticity of demand sounds a lot like the slope of the demand curve: how much quantity demanded changes when price does. Although elasticity and slope are certainly related, they're not the same.

The slope relates a change in one level (prices) to another level (quantity). The demand curve we introduced in the tomato example was

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The slope of this demand curve is

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that is, quantity demanded falls by 200 pounds for every dollar per pound increase in price.

There are two big problems with using just the slopes of demand and supply curves to measure price responsiveness. First, slopes depend on the units of measurement. If we measured tomato prices *P* in cents per pound rather than dollars, the demand curve would be

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because the quantity of tomatoes demanded would fall by 2 pounds for every 1 cent increase in price. But the fact that the coefficient on *P* is now 2 instead of 200 doesn't mean that consumers are 1/100th as price-sensitive as before. Nothing has changed about consumers' price responsiveness in this market: The quantity demanded still falls by 200 pounds for each $1 increase in price. The change in the slope simply reflects a change in the units of *P*.

The second problem with slopes is that you can't compare them across different products. Suppose we were studying consumers' grocery shopping patterns and wanted to compare consumers' price sensitivity for tomatoes in the market at Pike Place Market to their price sensitivity for bunches of celery. Does the fact that consumers demand 100 fewer celery bunches for every 10-cent-per-bunch increase in price mean that consumers are more or less price-sensitive in the celery market than in the tomato market? The slope of the celery demand curve implied by these numbers is

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(if we measure quantity demanded in bunches and price in cents per celery bunch). How could we ever compare this slope to the

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slope for tomatoes?

Using elasticities to express responsiveness avoids these tricky issues, because everything is expressed in relative percentage changes. That eliminates the units problem (a 10% change is a 10% change regardless of what units the factor changing is measured in) and makes magnitudes comparable across markets.

The Price Elasticities of Demand and Supply

The price elasticity of demand is the ratio of the percentage change in quantity demanded to an associated percentage change in price. Mathematically, its formula is

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The **price elasticity of supply** is exactly analogous:

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To keep the equations simpler from now on, we'll use some shorthand notation.
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will denote the price elasticity of demand,
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the price elasticity of supply,
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and
Error parsing MathML: error on line 1 at column 881: Opening and ending tag mismatch: img line 0 and an
the percentage change in quantities demanded and supplied, respectively, and
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the percentage change in price. In this shorthand, the two equations above become

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price elasticity of supply
Price elasticity of supply = (% change in quantity supplied)/(% change in price)

So, for example, if the quantity demanded of a good falls by 10% in response to a 4% price increase, the good's price elasticity of demand is
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There are a couple of things to note about this example. First, because demand curves slope downward, the price elasticity of demand is always negative (or more precisely, always nonpositive; in special cases that we discuss later, it can be zero). Second, because it is a ratio, a price elasticity can also be thought of as the percentage change in quantity demanded for a 1% increase in price. That is, for this good, a 1% increase in price leads to a
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change in quantity demanded.

The price elasticity of supply works exactly the same way. If producers' quantity supplied increases by 25% in response to a 50% increase in price, for example, the price elasticity of supply is
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The price elasticity of supply is always positive (or again more precisely, always nonnegative) because quantity supplied increases when a good's price rises. And just as with demand elasticities, supply elasticities can be regarded as the percentage change in quantity in response to a 1% increase in price.

Price Elasticities and Price Responsiveness

Now that we've defined elasticities, let's use them to think about how responsive quantities demanded and supplied are to price changes.

When demand (supply) is very price-sensitive, a small change in price will lead to large changes in quantities demanded (supplied). That means the numerator of the elasticity expression, the percentage change in quantity, will be very large in magnitude compared to the percentage change in price in the denominator. For price elasticity of demand, the change in quantity will have the opposite sign as the price change, and the elasticity will be negative. But its magnitude (its absolute value) will be large if consumers are very responsive to price changes.

- *Markets with large price elasticities of demand—where quantity demanded is sensitive to price differences—are those where consumers have a lot of ability to substitute away from* *or toward the good in question.* The demand for apples at the grocery store is probably fairly price-responsive because consumers have an array of other fruits they can buy instead if apple prices are high; if apple prices are low, they will buy apples instead of other fruits. The price elasticity of demand for apples might be something like

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For every 1% increase in price, consumers' quantity demanded would fall by 4%.

- *Markets with less price-responsive elasticities of demand—where quantity demanded is fairly unresponsive to price changes—are those where consumers have fewer options for substitution.* The demand for cold drinks during a summer music festival probably has a fairly small price elasticity of demand. In this case, the price elasticity of demand might be something like

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  for every 1% increase in price, quantity demanded would fall by 0.3%. (If you prefer, you could also express this as saying for every 10% price increase, quantity demanded would drop by 3%.)
- *Markets with large price elasticities of supply—where the quantity supplied is sensitive to price differences—are those where it is easy for suppliers to vary their amount of production as price changes.* Perhaps they have a cost structure that allows them to make as many units as they'd like without driving up their per-unit costs too much. In the market for video games today, for example, if a new game becomes wildly popular and draws a high price, it's fairly easy for the game's producer to supply more downloads at very little additional cost. So, the elasticity of supply might be quite large in this market, something like 12 (a 1% increase in price leads to a 12% increase in quantity supplied).
- *Markets with low price elasticities of supply—where the quantity supplied is fairly unresponsive to price changes—are those where it is difficult to increase production.* This would occur in markets where it is costly for producers to vary their production levels, or it is difficult for producers to enter or exit the market. The supply curve for tickets to the Super Bowl might have a very low price elasticity of supply because there is only one Super Bowl game per year, and there are only so many seats in the stadium. If the ticket price rises today, the stadium owners can't really put in additional seats. The supply elasticity in this market might be close to zero. It's probably slightly positive, however, because the owners could open some obstructed-view seats or make other temporary seating arrangements.

Application: Demand Elasticities and the Availability of Substitutes

We discussed how the availability of substitutes can affect the price elasticity of demand. When consumers can easily switch to other products or markets, they will be more responsive to changes in the price of a particular good. This means that, for any small rise in price, there will be a large decline in quantity demanded and the price elasticity of demand will be relatively large (in absolute value).

Table 2.3 presents some other elasticities estimated by economists for various goods. Larger groupings like "juice" or "beef" tend to have inelastic demand. The more narrowly defined the goods are (and so the more substitute products there are), the more elastic the demand tends to be. Thus, the elasticity of beef is only

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whereas the elasticity of Shredded Wheat brand breakfast cereal is

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Table 2.3 Examples of Estimated Elasticities for Specific Goods

Product	Estimated Own-Price Elasticity of Dem
BROAD FOOD GROUPS	
Eggs	Error parsing MathML: error on line 10 at column 42: Opening and ending tag m
Beef	Error parsing MathML: error on line 9 at column 42: Opening and ending tag mi
Fish	Error parsing MathML: error on line 9 at column 42: Opening and ending tag mi
Juice	Error parsing MathML: error on line 9 at column 42: Opening and ending tag mi
SPECIFIC BREAKFAST CEREALS	
Cap'n Crunch	Error parsing MathML: error on line 9 at column 42: Opening and ending tag mi

Froot Loops	Error parsing MathML: error on line 9 at column 42: Opening and ending tag mi
Kellogg's Corn Flakes	Error parsing MathML: error on line 9 at column 42: Opening and ending tag mi
Cheerios	Error parsing MathML: error on line 9 at column 42: Opening and ending tag mi
Shredded Wheat	Error parsing MathML: error on line 9 at column 42: Opening and ending tag mi
SPECIFIC AUTOMOBILES	
Jeep Grand Cherokee	Error parsing MathML: error on line 9 at column 42: Opening and ending tag mi
Cadillac Seville	Error parsing MathML: error on line 9 at column 42: Opening and ending tag mi
Toyota Corolla	Error parsing MathML: error on line 9 at column 42: Opening and ending tag mi

Source: For food data: K. S. Huang and B. Lin, *Estimation of Food Demand and Nutrient Elasticities from Household Survey Data*, Technical Bulletin 1887, Food and Rural Economic Division, Economic Research Service, U.S. Department of Agriculture, August 2000. For cereal data: Aviv Nevo, "Measuring Market Power in the Ready-to-Eat Cereal Industry," *Econometrica* 69, no. 2 (March 2001): 307–342. For automobile data: Steven Berry, James Levinsohn, and Ariel Pakes, "Differentiated Products Demand Systems from a Combination of Micro and Macro Data: The New Car Market," *Journal of Political Economy* 112, no. 1, Part 1 (February 2004): 68–105.

In 2017, Amazon purchased the grocery chain Whole Foods and, in a very public fashion, cut the price of many items at Whole Foods stores. This decision was quite notable, especially given that even regular customers were known to refer to the chain as "Whole Paycheck"! One possible interpretation of this price-cutting strategy was that Amazon believed demand for many of the products sold at Whole Foods was more elastic than previous management did. It viewed the many options consumers have when buying groceries as creating fairly elastic demand for groceries. This ease of substitutability, even among those consumers who might be predisposed to like Whole Foods' offerings, meant the high prices kept away many potential customers. By cutting prices, the theory goes, Amazon expected to make a lot more sales (highly elastic demand works both ways—high prices cause a big loss in quantity, but low prices create big gains in quantity).

Time will tell if Amazon's beliefs about the demand elasticity for groceries are accurate. In the meantime, though, Whole Foods customers aren't paying quite so much for their organic quinoa as they used to. ■

Elasticities and Time Horizons

Often, a key factor determining the flexibility that consumers and producers have in responding to price differences, and therefore the price elasticity of their quantities demanded and supplied, is the time horizon.

In the short run, consumers are often limited in their ability to change their consumption patterns, but given more time, they can make adjustments that give them greater flexibility. A classic example of this is the market for gasoline. If a sudden price spike occurs, many consumers are essentially stuck having to consume roughly the same quantity of gas as they did before the price spike. After all, they have the same car, the same commute, and the same schedule as before. Maybe they can double up on a few trips, or carpool more often, but their ability to respond to prices is limited. For this reason, the short-run price elasticity of gasoline demand is relatively low; empirical estimates by economists who specialize in the market suggest that it is around

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That is, for a 1% change in the price of gas, the quantity demanded changes by only 0.2% in the direction opposite the price change. Over longer horizons, however, individuals have greater scope to adjust their consumption. If the gas spike lasts, they can set up a permanent ride-sharing arrangement, buy a more efficient car, or switch to public transportation. They might negotiate for remote work, or look for a new job closer to home (or a new home that's closer to work). The long-run price elasticity of demand for gasoline is therefore much larger in magnitude; empirical studies typically find it to be something like

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This means that in the long run, consumers can make four times the quantity adjustment to price changes they can make in the short run.

The same logic holds for producers and supply elasticities. The longer the horizon, the more options they have to adjust output to price changes. Manufacturers already producing at capacity might not be able to increase their output much in the short run if prices increase, even though they would like to. If prices stay high, however, they can hire more workers and build larger factories, and new firms can set up their own production operations and enter the market.

For these reasons, the price elasticities of demand and supply for most products are larger in magnitude (i.e., more negative for demand and more positive for supply) in the long run than in the short run. As we see in the next section, larger-magnitude elasticities imply flatter demand and supply curves. As a result, long-run demand and supply curves tend to be flatter than their short-run versions.

Classifying Elasticities by Magnitude

Economists have special terms for elasticities of particular magnitudes. Elasticities with magnitudes (in absolute value) greater than 1 are referred to as **elastic**. In the above examples, apples have elastic demand and software has elastic supply. Elasticities with magnitudes less than 1 are referred to as **inelastic**. The demand for circus candy and the supply of Super Bowl tickets are inelastic. If the price elasticity of demand is exactly

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or the price elasticity of supply is exactly 1, this is referred to as **unit elastic**. If price elasticities are zero—that is, there is no response in quantity to price changes—the associated goods are called **perfectly inelastic**. Finally, if price elasticities are infinite in magnitude

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for demand,

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for supply)—the quantity demanded or supplied changes infinitely in response to any price change—this is referred to as **perfectly elastic**.

elastic
A price elasticity with an absolute value greater than 1.

inelastic
A price elasticity with an absolute value less than 1.

unit elastic
A price elasticity with an absolute value equal to 1.

perfectly inelastic
A price elasticity that is equal to zero; there is no change in quantity demanded or supplied for any change in price.

perfectly elastic
A price elasticity that is infinite; any change in price leads to an infinite change in quantity demanded or supplied.

Elasticities and Linear Demand and Supply Curves

As we discussed above, economists often use linear (straight-line) demand and supply curves, mostly for the sake of convenience. Because they are so common, it's worth discussing how elasticities are related to linear curves. Even more important, drawing this connection shows exactly how curves' slopes and elasticities, the two measures of price responsiveness we've been using, are related but still different.

We can rewrite the elasticity formula in a way that makes it easier to see the relationship between elasticity and the slope of a demand or supply curve. A percentage change in quantity

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is the change in quantity

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divided by the original quantity level Q. That is,

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Similarly, the percentage change in price is

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Substituting these into the elasticity expression from above, we have

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where E is a demand or supply elasticity, depending on whether Q denotes quantity demanded or supplied.

Rearranging terms yields

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or

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where “slope” refers to
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the slope of the demand or supply curve in the standard price-versus-quantity space.

Elasticity of a Linear Demand or Supply Curve

Suppose we’re dealing with the demand curve in **Figure 2.13**. Its slope is
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but its elasticity varies as we move along it because
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does. Think first about the point *A*, where it intercepts the vertical axis. At
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is infinite because *P* is positive ($20) and *Q* is zero. This, combined with the fact that the curve’s (constant) slope is negative, means the price elasticity of demand is
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at this point. The logic behind this is that consumers don’t demand any units of the good at *A* when its price is $20, but if price falls at all, their quantity demanded will become positive, if still small. Even though this change in quantity demanded is small in numbers of units of the good, the *percentage* change in consumption is infinite, because it’s rising from zero.

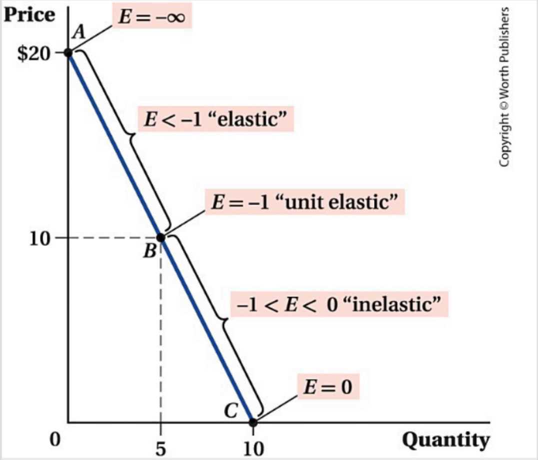

Figure 2.13 Elasticity of a Linear Demand Curve

The ratio between price and quantity
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and the magnitude of the elasticity of a demand curve decrease as we move down the curve. At point *A*,
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and the price elasticity of demand is
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Between points *A* and *B*, the demand curve is elastic with a price elasticity of demand less than
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(greater than 1 in absolute value). At point *B*, the demand curve is unit elastic, or the price elasticity of demand equals
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Between points *B* and *C*, the demand curve is inelastic with a price elasticity of demand greater than
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(less than 1 in absolute value). At point *C*,
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and the price elasticity of demand equals zero.

As we move down along the demand curve, the

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ratio falls, reducing the magnitude of the price elasticity of demand. (Remember, the slope isn't changing so that part of the elasticity stays the same.) It will remain elastic—that is, have a magnitude larger than 1—for some distance. Eventually, the absolute value of the elasticity will fall to 1, and at that point the demand curve is unit elastic. For the curve in Figure 2.13, this happens to be when

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and

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because

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This is labeled point *B* in the figure.[9] As we continue down and to the right along the demand curve, the magnitude of the elasticity will fall further and demand will become inelastic. At the point where the demand curve hits the horizontal axis (point *C* in the figure), price is zero, so

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and the price elasticity of demand is zero.

A similar effect happens as we move along a linear supply curve. Again, because the slope of the curve is constant, the changes in elasticity along the curve are driven by the price-to-quantity ratio. At the point where the supply curve intercepts the vertical axis, the quantity is 0 and

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is infinite. The price elasticity of supply is

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at this point. The same logic holds as with the demand curve: For the smallest increase in price, the quantity supplied rises from zero to a positive number, an infinite percentage change in quantity supplied.

As we move up along the supply curve, the

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ratio falls. It's probably obvious that it must fall from infinity, but you might wonder whether it keeps falling, because both *P* and *Q* are rising. It turns out that, yes, it must keep falling. Unlike with the demand curve, however, the

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ratio never falls to zero because the supply curve will never intercept the horizontal axis. Therefore, the price elasticity of supply won't drop to zero.

Perfectly Inelastic and Perfectly Elastic Demand and Supply

The formula relating elasticities to slopes also sheds some light on what demand and supply curves look like in two special but often discussed cases: perfectly inelastic and perfectly elastic demand and supply.

Perfectly Inelastic

We discussed above that when the price elasticity is zero, demand and supply are said to be perfectly inelastic. But what would a demand curve look like that is perfectly inelastic everywhere? A linear demand curve with a slope of

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would drive the price elasticity of demand to zero because elasticity and slope are inversely related. Because a curve with an infinite slope is vertical, a perfectly inelastic demand curve is vertical. An example of such a curve is shown in **Figure 2.14a**. This makes intuitive sense: A vertical demand curve indicates that the quantity demanded by consumers is completely unchanged regardless of the price. Any percentage change in price will induce a 0% change in quantity demanded. In other words, the price elasticity of demand is zero.

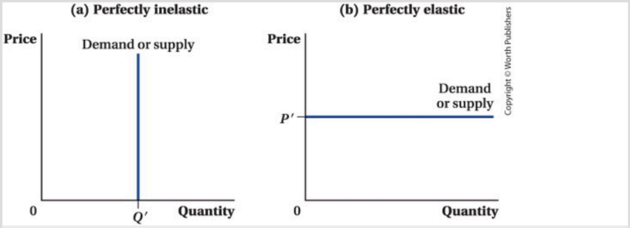

Figure 2.14 Perfectly Inelastic and Perfectly Elastic Demand or Supply Curves

(a) When a demand or supply curve is vertical, its slope is infinite and it is perfectly inelastic. In other words, any change in price will result in a 0% change in quantity demanded or supplied.

(b) When a demand or supply curve is horizontal, its slope is zero and it is perfectly elastic. In other words, any change in price will result in an infinitely large change in quantity demanded or supplied.

Although perfectly inelastic demand curves don't really exist (after all, there are almost always possibilities for consumers and producers to substitute toward or away from a good as prices hit either extreme of zero or infinity), we might see some situations approaching them. For example, people with diabetes might have very inelastic demand for insulin. Their demand curve will be almost vertical if they will buy it at any price.

The same logic holds for supply: A vertical supply curve indicates perfectly inelastic supply and no response of quantity supplied to price differences. The supply of tickets for a particular concert or sporting event might also be close to perfectly inelastic, with a near-vertical supply curve, due to capacity constraints of the arena.

One implication of perfect inelasticity is that any shift in the market's demand or supply curve will result in a change only in the market equilibrium price, not the quantity. That's because there is absolutely no scope for quantity to change in the movement along a perfectly inelastic demand curve from the old to the new equilibrium. Likewise, for perfectly inelastic supply, if there is a demand curve shift, all equilibrium movement occurs in price, not quantity.

figure it out 2.5

The demand for gym memberships in a small rural community is Error parsing MathML: error on line 1 at column 860: Opening and ending tag mismatch: img line 0 and annotation-xml, where *Q* is the number of monthly members and *P* is the monthly membership rate.

a. Calculate the price elasticity of demand for gym memberships when the price is $50 per month.
b. Calculate the price elasticity of demand for gym memberships when the price is $100 per month.
c. Based on your answers to (a) and (b), what can you tell about the relationship between price and the price elasticity of demand along a linear demand curve?

Solution:

a. The price elasticity of demand is calculated as

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Let's first calculate the slope of the demand curve. The easiest way to do this is to rearrange the equation in terms of *P* to find the inverse demand curve:

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We can see that the slope of this demand curve is Error parsing MathML: error on line 1 at column 655: Opening and ending tag mismatch: img line 0 and annotation-xml. We know this because every time *Q* rises by 1, *P* falls by 0.5.

Thus, we now know the slope and the price. To compute the elasticity, we need to know the quantity demanded at a price of $50. To determine this, we plug $50 into the demand equation for *P*:

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Now we are ready to compute the elasticity:

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b. When the price is $100 per month, the quantity demanded is

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Plugging into the elasticity formula, we get

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c. From (a) and (b), we can see that as the price rises along a linear demand curve, demand moves from being inelastic

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to elastic

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Perfectly Elastic

When demand or supply is perfectly elastic, on the other hand, the price elasticity is infinite. This will be the case for linear demand or supply curves that have slopes of zero—those that are horizontal. An example of such a curve is shown in Figure 2.14b. This shape makes intuitive sense, too. As flat demand or supply curves imply large quantity responses to price changes, *perfectly* flat curves imply infinitely large quantity responses to price changes. If price is just above a horizontal demand curve, the quantity demanded will be zero. But if price fell just a bit, to below the demand curve, the quantity demanded would be infinite. Similarly, a small price change from above to below a horizontal supply curve would shift producers' quantity supplied from infinity to zero.

Small producers of commodity goods probably face demand curves for their products that are approximately horizontal. (We'll discuss this in depth in Chapter 8.) For instance, a small corn farmer can probably sell as many bushels of corn as they want at the market price. If the farmer decided that the price was too low and insisted that they be paid more than the going rate, no one would buy their corn. Consumers could buy from someone else for less. Effectively, then, it is as if the farmer faces an infinite quantity demanded for their corn at the going price (or below it, if for some reason they're willing to sell for less) but zero quantity demanded of their corn above that price. In other words, they face a flat demand curve at the going market price.

Supply curves are close to perfectly elastic in competitive industries in which producers all have roughly the same costs, and entry and exit are very easy. (We'll also discuss this point at greater length in Chapter 8.) These conditions mean that competition will drive prices toward the (common) level of costs, and differences in quantities supplied will be soaked up by the entry and exit of firms from the industry. Because of competition in the market, no firm will be able to sell at a price above costs, and obviously no firm will be willing to supply at a price below costs. Therefore, the industry's supply curve is essentially flat at the producers' cost level.

As opposed to the perfectly inelastic case, shifts in supply in a market with perfectly elastic demand will only move equilibrium quantity, not price. There's no way for the equilibrium price to change when the demand curve is flat. Similarly, for markets with perfectly elastic supply, demand curve shifts move only equilibrium quantities, not prices.

The Factors in "Everything Else"

➡ Appendix 2A, The Calculus of Equilibrium and Elasticities, calculates and applies different demand and supply elasticities.

We've been focusing on price elasticities to this point, and with good reason: They are a key determinant of demand and supply behavior and play an important role in helping us understand how markets work. However, they are not the only elasticities that matter in demand and supply analysis. Remember how we divided up all the factors that affected demand or supply into two categories: price and everything else? Well, each of those other factors that went into "everything else" has an influence on demand or supply that can be measured with an elasticity. The most commonly used of these elasticities measure the impact of two other factors on quantity demanded: the income elasticity of demand and the cross-price elasticity of demand.

Income Elasticity of Demand

The **income elasticity of demand** is the ratio of the percentage change in quantity demanded to the corresponding percentage change in consumer income (I):

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income elasticity of demand
The ratio of the percentage change in quantity demanded to the corresponding percentage change in consumer income.

(Equivalently, it is the percentage change in quantity demanded associated with a 1% change in consumer income.)

Income elasticities describe how responsive demand is to income changes. Goods are sometimes categorized by the sign and size of their income elasticity.

- Goods with positive income elasticities (consumers demand a higher quantity of the good when their income increases) are called **normal goods**. As the name indicates, most goods fit into this category, including restaurant meals, smartphones, and streaming subscriptions.
- Normal goods with income elasticities above 1 are sometimes called **luxury goods**. Having an income elasticity that is greater than 1 means the quantity demanded of these products rises at a faster rate than income. As a consequence, the share of a consumer's budget that is spent on a luxury good becomes larger as the consumer's income rises. (To keep a good's share of the budget constant, quantity consumed would have to rise at the same rate as income. Because luxury goods' quantities rise faster, their share increases with income.) Private jets, personal chefs, and fine art are all luxury goods.
- Goods with negative income elasticities (consumers demand a lower quantity of the good when their income rises) are called **inferior goods**. Note that the word "inferior" isn't a comment on the inherent quality of the good; it just describes how people's consumption changes with incomes. (Low-quality versions of many products are inferior goods by this economic definition, but the term can also refer to goods of almost identical quality—like generic versions of name-brand medications.) Examples of likely inferior goods are public transportation, youth hostels, and hot dogs.

normal good
A good for which quantity demanded rises when income rises.

luxury good
A good with an income elasticity greater than 1.

inferior good
A good for which quantity demanded decreases when income rises.

We will dig deeper into the relationship between incomes and consumer demand in Chapters 4 and 5.

Cross-Price Elasticity of Demand

The **cross-price elasticity of demand** is the ratio of the percentage change in one good's quantity demanded (say, good *X*) to the percentage change in the price of another good (*Y*):

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cross-price elasticity of demand
The ratio of the percentage change in one good's quantity demanded (say, good *X*) to the percentage change in the price of another good *Y*.

(To avoid confusion, sometimes the price elasticities we discussed above, which are concerned with the percentage change in quantity demanded to the percentage change in the price of the same good, are referred to as **own-price elasticities of demand**.)

own-price elasticities of demand
The percentage change in quantity demanded for a good resulting from a percentage change in the price of that good.

When a good has a positive cross-price elasticity with another good, that means consumers demand a higher quantity of it when the other good's price rises. In other words, the good is a substitute for the other good: Consumers switch to the good when the other one becomes more expensive. Many pairs of goods are substitutes for one another—different brands of cereal, meals at restaurants versus dinners at home, colleges, and so on. Economist Aviv Nevo, who measured the elasticities for cereals mentioned above, also measured the cross-price elasticities of the cereals. He found that Froot Loops, for example, is a substitute for other kids' cereals, like Frosted Flakes and Cap'n Crunch (Error parsing MathML: error on line 1 at column 1038: Opening and ending tag mismatch: img line 0 and and 0.149, respectively). However, it is much less of a substitute for the more adult

Shredded Wheat, which had a cross-price elasticity of only 0.020.[10]

figure it out 2.6

Suppose that the price elasticity of demand for cereal is
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and the cross-price elasticity of demand between cereal and the price of milk is
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If the price of milk rises by 10%, what would have to happen to the price of cereal to exactly offset the rise in the price of milk and leave the quantity of cereal demanded unchanged?

Solution:

The first step will be to see what happens to the quantity of cereal demanded when the price of milk rises by 10%. We can use the cross-price elasticity to help us determine this. The cross-price elasticity for cereal with respect to the price of milk is equal to
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Using the equation, we know that the denominator is 10 since the price of milk rose by 10%, so we get

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Thus, when the price of milk rises by 10%, the quantity of cereal demanded falls by 9%.

Now we must consider how to offset this decline in the quantity of cereal demanded with a change in the price of cereal. In other words, what must happen to the price of cereal to cause the quantity of cereal demanded to *rise* by 9%? It is clear that the price of cereal must fall because the law of demand suggests that an inverse relationship exists between price and quantity demanded. However, because we know the price elasticity of demand, we can actually determine how far the price of cereal needs to fall.

The price elasticity of demand for cereal is

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To offset the decline in cereal consumption caused by the rise in the price of milk, we need the percentage change in quantity demanded to be
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Therefore, we can plug 9% into the numerator of the ratio and solve for the denominator:

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The price of cereal would have to fall by 12% to exactly offset the effect of a rise in the price of milk on the quantity of cereal consumed.

When a good has a negative cross-price elasticity with another good, consumers demand less of it when the other good's price increases. This indicates that the goods are complements. Complements tend to be goods that are consumed together. If either of the goods within each pair were to become more expensive, consumers would buy not just less of that good itself, but also less of the other good in the pair. Milk and cereal are complements, as are tennis rackets and tennis balls, or computers and software.

2.6 Conclusion

This chapter introduced the concepts of supply and demand, two of the most important ideas in economics. Using the simplified supply and demand framework, we examined a variety of topics, including equilibrium price and quantity, the effects of shocks to supply and demand, and elasticities.

Nevertheless, the various cases we looked at in this chapter are, for the most part, simplified and abstract. In reality, measuring a market's demand and supply curves and determining the equilibrium price and quantity can be quite complicated. For example, firms hoping to make production decisions based on the types of analysis we've done here need to consider a wide range of data—prices, elasticities, demand curves, and so on—that are often not known. As a result, producers might rely on more trial-and-error practices than allowed for in our simplified model. Beginning with Chapter 6 and continuing through Part 3: Markets and Prices, we will talk more about situations that producers face in the real world and the production decisions that they must make, such as how much of a product to produce, how to produce it, and if they should enter a particular market at all. And we will see how these decisions are reflected in a firm's supply curve. In the meantime, the simplified supply and demand framework we've developed here provides a valuable structure for delving into a deeper analysis of markets and equilibrium price and quantity in upcoming chapters.

Summary

1. Economists use models to analyze markets. Models employ simplifying assumptions to reduce the incredible complexity of the real world so that general insights can be learned. The **supply and demand** model is one of the most used analytical frameworks in economics. This model makes several assumptions about the market that is being analyzed, including that all goods bought and sold in the market are identical, they are all sold for the same price, and there are many producers and consumers in the market. **[Section 2.1]**
2. Demand describes the willingness of consumers to purchase a product. There are many factors that affect demand, including price, income, quality, tastes, and availability of **substitutes and complements.** Economists commonly use the concept of a **demand curve,** which essentially divides these factors into two groups: price and everything else. A demand curve relates consumers' quantity demanded to the price of the good while holding every other factor affecting demand constant. A change in a good's price results in a movement along a given demand curve. If nonprice factors change, the quantity demanded at every price changes and the whole demand curve shifts. **[Section 2.2]**
3. Supply describes the willingness of producers to make and sell a product. Factors that affect supply include price, available **production technologies,** input prices, and producers' outside options. **Supply curves** isolate the relationship between quantity supplied and price, holding all other supply factors constant. A change in a good's price results in a movement along a given supply curve. If nonprice factors change, the quantity supplied at every price changes and the whole supply curve shifts. **[Section 2.3]**
4. Combining demand and supply curves lets us determine the **market equilibrium** price, which is where quantity demanded equals quantity supplied. This equilibrium can be determined because demand and supply curves isolate the relationships between quantities and the one factor that affects both demand and supply: price. At the equilibrium, every consumer who wants to buy at the going price can, and every producer who wants to sell at the current market price can as well. **[Section 2.4]**

5. Changes in the factors (other than price) that affect demand or supply will change the market equilibrium price and quantity. Changes that increase demand and shift out the demand curve will raise **equilibrium price** and quantity in the absence of supply shifts; when the changes decrease demand and shift the demand curve in, price and quantity will fall. Changes that increase supply and shift out the supply curve, assuming no change in the demand curve, will increase equilibrium quantity and reduce price. Changes that decrease supply and shift in the supply curve decrease quantity and raise price. **[Section 2.4]**
6. If both supply and demand shift, either the effect on equilibrium price or the effect on equilibrium quantity will be ambiguous. If supply and demand move in the same direction, equilibrium quantity will follow, but the impact on price is unknown. On the other hand, if supply and demand move in opposite directions, equilibrium price will move in the same direction as demand (increase when demand rises, fall when demand decreases), but we cannot say with certainty what the effect on equilibrium quantity will be. **[Section 2.4]**
7. Economists typically express the sensitivity of demand and supply to various factors, but especially price, in terms of elasticities. An **elasticity** is the ratio of the percentage changes in two variables. The **price elasticity of demand** is the percentage change in quantity demanded for a 1% change in price, and the **price elasticity of supply** is the percentage change in quantity supplied for a 1% price change. **[Section 2.5]**
8. Other common demand elasticities measure the responsiveness of quantity demanded to changes in income and the prices of other goods. The **income elasticity of demand** is positive for **normal goods** and negative for **inferior goods.** The **cross-price elasticity of demand** is positive for substitutes and negative for complements. **[Section 2.5]**

Review Questions

1. There are four key assumptions underlying the supply and demand model. Name these assumptions.
2. Complements and substitutes of a given good affect the demand for that good. Define complements and substitutes.
3. What simplifying assumption do we make to build a demand curve? Why is the demand curve downward-sloping?
4. What is the difference between a change in quantity demanded and a change in demand?
5. What form do inverse supply and demand equations take? Why do economists often represent supply and demand using the inverse equations?
6. Why is the supply curve upward sloping?
7. What is the difference between a change in quantity supplied and a change in supply?
8. Define market equilibrium. What is true of the quantity supplied and demanded at the market equilibrium?
9. What happens when price is below the equilibrium price? Why?
10. In what direction will price and quantity move as a result of a demand shift?
11. In what direction will price and quantity move as a result of a supply shift?
12. Why is the direction of change of *either* price *or* quantity unknown when both supply and demand shift?
13. What happens to equilibrium price when supply and demand shift in the same direction? What happens to equilibrium quantity in the same situation?

14. What is the difference between an elasticity and slope?

15. We learned that economists have special terms for elasticities of particular magnitudes. Name the magnitudes for the following: inelastic, elastic, unit elastic, perfectly elastic, and perfectly inelastic.

16. Using the concept of income elasticity of demand, describe normal, luxury, and inferior goods.

17. Using the concept of cross-price elasticity of demand, describe substitutes and complements.

Problems

1. One assumption of the supply and demand model is that all goods bought and sold are identical. Why do you suppose economists commonly make this assumption? Does the supply and demand model lose its usefulness if goods are not identical?

2. List the assumptions of the supply and demand model. Then, for each assumption, give one example of a market in which the assumption is satisfied, and one example of a market in which that assumption is not satisfied. Is it reasonable to use the supply and demand model when assumptions are violated?

3. The demand for organic carrots is given by the following equation:
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   where
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   is the price of organic carrots,
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   is the price of conventional carrots, and *I* is the average consumer income. Notice how this isn't a standard demand curve that just relates the quantity of organic carrots demanded to the price of organic carrots. This demand function also describes how other factors affect demand—namely, the price of another good (conventional carrots) and income.

   a. Graph the inverse demand curve for organic carrots when
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      and
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      What is the choke price?

   b. Using the demand curve drawn in (a), what is the quantity demanded of organic carrots when

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When

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c. Suppose

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increases to 15, while *I* remains at 10. Calculate the quantity demanded of organic carrots. Show the effects of this change on your graph and indicate the choke price. Has there been a change in the demand for organic carrots, or a change in the quantity demanded of organic carrots?

d. What happens to the demand for organic carrots when the price of conventional carrots increases? Are organic and conventional carrots complements or substitutes? How do you know?

e. What happens to the demand for organic carrots when the average consumer's income increases? Are carrots a normal or an inferior good?

4. Out of the following events, which are likely to cause the demand for coffee to increase? Explain your answers.

   a. An increase in the price of tea

   b. An increase in the price of doughnuts

   c. A decrease in the price of coffee

   d. The Surgeon General's announcement that drinking coffee lowers the risk of heart disease

   e. Heavy rains causing a record-low coffee harvest in Colombia

5. How is each of the following events likely to shift the supply curve or the demand curve for fast-food hamburgers in the United States? Make sure you indicate which curve (curves) is affected and if it shifts out or in.

   a. The price of beef triples.

   b. The price of chicken falls by half.

   c. The number of teenagers in the economy falls due to an aging population.

   d. Mad cow disease, a rare but fatal medical condition caused by eating tainted beef, becomes common in the United States.

   e. The Food and Drug Administration publishes a report stating that a certain weight-loss diet, which encourages the intake of large amounts of meat, is dangerous to one's health.

   f. An inexpensive new grill for home use that allows consumers to make delicious hamburgers is heavily advertised on television.

   g. The minimum wage rises.

6. The supply of wheat is given by the following equation:

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   where

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   is the quantity of wheat supplied, in millions of bushels;

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   is the price of wheat per bushel;

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   is the price of corn per bushel; and

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   is the price of tractor fuel per gallon.

   a. Graph the inverse supply curve when corn sells for $4 a bushel and fuel sells for $2 a gallon. What is the supply choke price?

   b. How much wheat will be supplied at a price of $4? $8?

   c. What will happen to the supply of wheat if the price of corn increases to $6 per bushel? Explain intuitively; then graph the new inverse supply carefully and indicate the new choke price.

d. Suppose instead that the price of corn remains $4, but the price of fuel decreases to $1. What will happen to the supply of wheat as a result? Explain intuitively; then graph the new inverse supply. Be sure to indicate the new choke price.

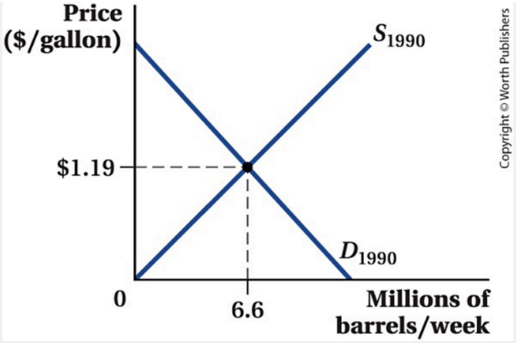
7. Bitcoin and other cryptocurrencies are demanded by those who wish to use them to complete transactions or those who wish to speculate on their future value. Bitcoins are supplied by thousands of competing miners who harness computing power to “dig” for Bitcoins by solving math problems. The more Bitcoins mined, the more difficult the math problems become.

   a. Use information in the chapter opener to explain why the supply curve of Bitcoins is likely to be upward-sloping.

   b. Increases in computing speed have, all else equal, made it easier for miners to mine Bitcoins. Draw a properly labeled graph showing how an increase in computing power affects the supply of Bitcoins.

   c. Suppose that the only change in the market for Bitcoins is the change described in (b). How would that change affect the equilibrium price and quantity of Bitcoins sold?

8. In March 2002 the retail price of gasoline was $1.19 per gallon—exactly the same as it was in August 1990. Yet, total gasoline production and consumption rose from 6.6 million barrels per week in 1990 to 8.7 million barrels per week in 2002. Using the graph below, draw the appropriate shifts in the demand and supply curves to explain these two phenomena.



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9. When the demand for toilet paper increases, the equilibrium quantity sold increases. Consumers are buying more, and producers are producing more.

   a. How do producers receive the signal that they need to increase production to meet the new demand?

   b. Based on the facts given above, can you say that an increase in the demand for toilet paper causes an increase in the supply of toilet paper? Carefully explain why or why not.

10. Suppose the demand for towels is given by

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    and the supply of towels is given by

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    a. Derive and graph the inverse supply and inverse demand curves.

    b. Solve for the equilibrium price and quantity.

    c. Suppose that supply changes so that at each price, 20 fewer towels are offered for sale. Derive and graph the new inverse supply curve.

d. Solve for the new equilibrium price and quantity. How does the decrease in supply affect the equilibrium price and quantity sold?

e. Suppose instead that supply does not change, but demand decreases so that at each price, 25 fewer towels are desired by consumers. Solve for the new equilibrium price and quantity. How does the decrease in demand affect the equilibrium price and quantity sold? How do those changes compare to your response in (d)?

11. The market for whisky in Scotland is described by the following demand and supply equations:

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where *P* is the price of a liter of whisky and *Q* is the number of liters sold per week, in thousands. Suppose the Scottish government mandates a price of £60 per liter.

a. Is the market in equilibrium? Why or why not?

b. At the government's price, is there an excess demand or excess supply of whisky?

c. Suppose that the government decides to let the price of whisky be determined by the market rather than by the government. Based on your answer to (b), would you expect the price of whisky to increase, decrease, or stay the same? Explain your reasoning intuitively.

12. The inverse demand for carbon-steel chef's knives is given by

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where *P* is the price of a chef's knife and

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is the quantity of chef's knives desired per week, in thousands. The inverse supply of chef's knives is given by

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where

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is the quantity of chef's knives offered for sale each week, in thousands.

a. Accurately graph the inverse supply and inverse demand curves, with *P* on the vertical axis and *Q* on the horizontal axis.

b. What are the buyers' and sellers' choke prices in your graph? How can you find those same choke prices by looking at the inverse demand and inverse supply equations?

c. Equate inverse demand and inverse supply to find the market equilibrium quantity of chef's knives sold. (*Hint:* In equilibrium,

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so you can replace both

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and

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with a generic letter *Q*.)

d. Plug the quantity you found in (c) into the inverse demand curve to solve for the equilibrium price. Then double-check your work by plugging that same quantity into the inverse *supply* curve.

13. In the United States, the biggest shopping day each year is "Black Friday," the day after Thanksgiving. Every Black Friday, the local branch of a major retailer makes this offer to the public: the first 100 54-inch HD flat-screen televisions sold will sell at the discounted price of $50 each. Customers line up before the store opens its doors to take advantage of this tremendous bargain.

a. In this scenario, what is the "price" of a 54-inch flat-screen television?

b. How would that "price" likely change if the retailer offered the first 500, instead of the first 100, televisions at $50 apiece? If only the first 50 were offered at the discounted price?

14. Determine the effects of the following events on the price and quantity of beer sold. Assume that beer is a normal good.

a. The price of wine, a substitute for beer, decreases.

b. The price of pizza, a complement to beer, increases.

c. The price of barley, an ingredient used to make beer, increases.

d. Brewers discover they can make more money producing wine than they can producing beer.

e. Consumers' incomes increase as the economy emerges from a recession.

15. Suppose the demand for down pillows is given by

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and that the supply of down pillows is given by

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a. Solve for the equilibrium price.

b. Plug the equilibrium price back into the demand equation and solve for the equilibrium quantity.

c. Double-check your work by plugging the equilibrium price back into the supply equation and solving for the equilibrium quantity. Does your answer agree with what you got in (b)?

d. Solve for the elasticities of demand and supply at the equilibrium point. Which is more elastic: demand or supply?

e. Invert the demand and supply functions (in other words, solve each for *P*) and graph them. Do the equilibrium point and relative elasticities shown in the graph appear to coincide with your answers?

16. In both the United States and France, the demand for haircuts is given by

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But in the United States, the supply is given by

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while in France, the supply is given by

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a. Graph supply and demand for haircuts for each country. (Use the same scale on each axis and graph carefully!)

b. Solve for the equilibrium price and quantity of a haircut in each country.

c. Suppose that the demand for haircuts in the United States increases by 100 units at each price, so the new demand is

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Place this new demand curve in the appropriate graph, and solve for the new equilibrium price and quantity in the United States.

d. Suppose that, in a similar fashion, the demand for haircuts in France increases by 100 units at each price. Add the new demand curve for haircuts to the appropriate graph, and solve for the new equilibrium price and quantity.

e. Drawing on your answers to (c) and (d), comment on the following statement: "The impact of an increase in *demand* depends critically on the slope of the *supply* curve."

17. Suppose that budding economist Buck measures the inverse demand curve for toffee as

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and the inverse supply curve as

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Buck's economist friend Penny likes to measure everything in cents. She measures the inverse demand for toffee as

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and the inverse supply curve as

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a. Find the slope of the inverse demand curve and compute the price elasticity of demand at the market equilibrium using Buck's measurements.

b. Find the slope of the inverse demand curve and compute the price elasticity of demand at the market equilibrium using Penny's measurements. Is the slope the same as Buck calculated? How about the price elasticity of demand?

18. Some policy makers have claimed that the U.S. government should purchase illegal drugs, such as cocaine, to increase the price that drug users face and therefore reduce their consumption. Does this idea have any merit? Illustrate this logic in a simple supply and demand framework. How does the elasticity of demand for illegal drugs relate to the efficacy of this policy? Are you more or less willing to favor this policy if you are told demand is inelastic?

19. Suppose that Jo has an inverse demand for frogs' legs given by

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while Kyle's inverse demand for frogs' legs is given by

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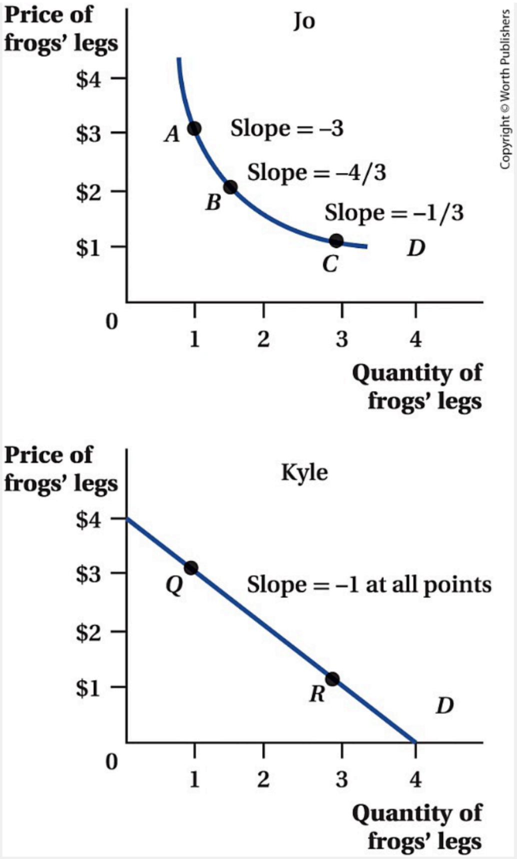
Graphs of each consumer's demand curve are shown below.



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a. Show that Jo’s demand for frogs’ legs is unit elastic.

b. Show that Kyle’s elasticity of demand for frogs’ legs differs at different points on his demand curve.

c. Use your answers to (a) and (b) to comment on the difference between the slope of a demand curve and the elasticity of demand.

20. The cross-price elasticity of demand measures the percentage change in the quantity of a good demanded when the price of a different good changes by 1%. The income elasticity of demand measures the percentage change in the quantity of a good demanded when the income of buyers changes by 1%.

a. What sign might you expect the cross-price elasticity to have if the two goods are shampoo and conditioner? Why?

b. What sign might you expect the cross-price elasticity to have if the two goods are gasoline and ethanol? Why?

c. What sign might you expect the cross-price elasticity to have if the two goods are coffee and shoes? Why?

d. What sign might you expect the income elasticity to have if the good in question is hot stone massages? Why?

e. What sign might you expect the income elasticity to have if the good in question is Ramen noodles? Why?

f. What sign might you expect the income elasticity to have if the good in question is table salt? Why?

21. Which of the following cases will result in the largest decrease in equilibrium price? The largest change in equilibrium quantity? Verify your answers by drawing graphs.

a. Demand is highly inelastic; there is a relatively large increase in supply.

b. Demand is highly elastic; there is a relatively small increase in supply.

c. Supply is highly inelastic; there is a relatively small decrease in demand.

d. Supply is highly elastic and demand is very inelastic; there is a relatively large increase in supply.

Appendix 2A:

The Calculus of Equilibrium and Elasticities

This text provides a number of math supplements, including the chapter Figure It Out features, the end-of-chapter calculus appendices (included with chapters 4, 5, 6, 7, and 9), and a Math Review (located at the back of the book). Why add another appendix? These additional appendices give us an opportunity to illustrate additional—and often more advanced—mathematical techniques that can be applied to the economics you learn throughout the course. Some of these supplemental appendices will build on concepts explored in the chapters themselves, whereas others will provide richer detail on the mathematics in the chapter-ending calculus appendices. As with the other math supplements, the appendices provide information and techniques that may further your understanding of economics, but are not intended as substitutes for what you would learn in your college mathematics courses.

In this appendix, we use calculus to describe the effect of changes in variables other than the good's own price on equilibrium outcomes. We also calculate and apply a variety of supply and demand elasticities using calculus, enabling us to calculate elasticities in a wider variety of circumstances than those shown in the text.

Demand

A **demand curve** is a representation of a relationship between the quantity of a good that consumers demand and that good's price, holding all other factors constant. Let's consider the hypothetical linear demand curve for tomatoes from the text:

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where

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is the quantity demanded of tomatoes in pounds and *P* is the price in dollars per pound. Note that this demand equation is written so that quantity is a function of price only.

demand curve
The relationship between the quantity of a good that consumers demand and the good's price, holding all other factors constant.

The definition of a demand curve, however, is more general. Particularly, it specifies that demand may also depend on "other factors" (which we then hold constant for our calculations of demand curves). In the chapter we learned that when other factors change (such as changes in income, the prices of related goods, or tastes), the demand curve shifts. It is therefore useful to think about an "expanded" demand function for which quantity demanded is a function not only of the good's own price but also of some of these other factors.

As a relatively simple example, consider adding the prices of related goods and income to the linear demand curve:

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where

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and

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are the prices of a substitute good and of a complementary good respectively and *I* is income. Why might we include the prices of substitute and complementary goods in the demand curve for tomatoes? As we saw in the text, a change in the price of a substitute for a good (a good that can be used in place of another good) affects demand for the original good. Similarly, a change in the price of a good that is used in combination with another (a complement) also affects the good's demand.

Let's use the demand for tomatoes to explore these relationships more fully. Suppose peppers are a substitute for tomatoes with price

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and the people enjoy eating lettuce with tomatoes, so it is a complementary good with price

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Assume lettuce and peppers each cost $1 per unit, and that the average consumer income is $60,000. Note that at these values

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Simplifying this, we see that the demand curve written only as a function of price is

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—the same relationship as in the text!

What happens if the price of peppers—the substitute—increases to $2? An increase in the price of a substitute product increases the quantity demanded of the original good at all prices, all else equal, thereby shifting the original demand curve to the right. We can see this by plugging the new price of peppers into the original demand curve:

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The slope[1] of the demand curve is the same:

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Because the intercept[2] has increased from 5 to 5.5, the price increase has resulted in a parallel shift up and to the right of the demand curve.

Now let's add another layer of changes to the demand curve. Suppose that the price of lettuce increases to $2. The quantity demanded of tomatoes becomes

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In this example, the price increases of peppers and lettuce are equivalent—both the substitute and complement experienced price increases from $1 to $2. You might then expect that these two price increases would cause demand shifts of equivalent magnitudes. Instead, given this particular demand function, the effect (shift of the demand curve down and to the left) of the increase in the price of lettuce (a complement to tomatoes) more than offsets the magnitude of the rightward shift due to the increased price of peppers (the substitute good). As a result, the new demand curve lies to the left of the original demand curve. We can use partial derivatives to show differences in the magnitudes of the two effects and to draw further conclusions.

Because the demand curve is now multivariable (quantity demanded depends not just on own price, but many other variables as well), it is useful to consider what the partial derivatives reviewed in the book's Math Review tell us in this context. As a starting point, consider the partial derivative of the demand curve with respect to its own price

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This partial derivative isolates the effect of own price *P* on quantity demanded

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It can be interpreted similarly to

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studied in the text. The partial derivative holds all the other factors in our multivariable setting constant.

Next, consider the partial derivative of the demand curve with respect to the price of the substitute good

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This partial derivative isolates the effect of the substitute's price

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on quantity demanded

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holding everything else constant. Likewise, the partial derivative of the demand curve with respect to the complement good's price

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isolates the effect of

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on

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holding everything else constant. Finally,

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isolates the effect of income on quantity demanded, holding everything else constant.

We can use the partial derivatives of quantity demanded with respect to each variable to demonstrate a series of economic concepts from Chapter 2. Going back to our example,

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note that

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(1)

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(2)

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(3)

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(4)

What do these partial derivatives tell us about the demand for this product (tomatoes)? First, most demand curves are downward-sloping by the law of demand, which states that as price increases, quantity demanded decreases, all else equal. This is precisely what the negative relationship in (1) tells us.

Partial derivatives with respect to the prices of other goods can tell us whether a good is a substitute (2) or a complement (3). Recall that a substitute is a good for which a price increase translates into a quantity increase in the market for the original good and a complement is a good for which there is a negative relationship between the price in one market and the quantity demanded in another. Expressed mathematically in terms of calculus, this means that
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and
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exactly as shown in (2) and (3).

The partial derivative with respect to income (4) can reveal whether we are dealing with a normal or an inferior good. Recall that a normal good is a good for which quantity demanded rises when income rises and an inferior good is a good for which quantity demanded decreases when income rises. In terms of calculus, this means that
Error parsing MathML: error on line 1 at column 1458: Opening and ending tag mismatch: img line 0 and a
for a normal good and
Error parsing MathML: error on line 1 at column 1383: Opening and ending tag mismatch: img line 0 and a
for an inferior good.[3] Because we find a positive relationship between income and quantity demanded for our tomato example in (4), we know that tomatoes are normal goods in this particular case.

Supply

A **supply curve** illustrates the relationship between the quantity supplied of a good and its price, holding all other factors constant. The supply curve we examine for tomatoes is
Error parsing MathML: error on line 1 at column 1075: Opening and ending tag mismatch: img line 0 and a
As in the demand case, this equation is written with quantity as a function of price alone, although changes in other factors can cause the supply curve to shift. Here, consider an "expanded" supply function where quantity supplied is a function not only of a good's own price but also of suppliers' costs of production. As an example, let's consider the case of tomato seeds and fertilizer, two inputs to the production of tomatoes. Now, quantity supplied can be written
Error parsing MathML: error on line 1 at column 1648: Opening and ending tag mismatch: img line 0 and a
where
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
is the price of input 1 and
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
is the price of input 2. In particular, let's set
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
to be the price of tomato seeds at $1 per pound, and
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
as the price of fertilizer at $10 per bag. Substituting into the supply relationship, we see that
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Note that this yields the same function for the supply curve as in the chapter.

supply curve
The relationship between the quantity supplied of a good and the good's price, holding all other factors constant.

We can analyze the effects of changes in input prices in a way that is similar to how we analyzed the effects on demand of changes in the prices of other goods and in income. Particularly, suppose that the price of fertilizer decreases to $5. Now,
Error parsing MathML: error on line 1 at column 2247: Opening and ending tag mismatch: img line 0 and a
When the price of an input falls, production becomes cheaper. The quantity supplied increases at every price, and the supply curve shifts out to the right. Note that in this example (like in the examples for demand shifts in the previous section), the change described is the result of a supply curve *shift*, as opposed to a movement along a given supply curve. When the price of fertilizer decreases, therefore,
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instead of

Error parsing MathML: error on line 1 at column 1005: Opening and ending tag mismatch: img line 0 and a

The supply curve has shifted because suppliers are now willing to produce more at every price.

Just as they are for demand, partial derivatives are a useful tool for further examining the effects of price changes on the supply of a good. Consider the partial derivative of the supply curve with respect to a good's own price

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This partial derivative now isolates the effect of own price *P* on quantity supplied

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and can be interpreted as the change in quantity supplied for a given change in price, holding all other factors in this multivariable setting constant. In our example,

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The fact that this partial derivative is positive is consistent with the law of supply, which indicates that as price increases, quantity supplied increases so that supply curves generally have a positive slope.

In addition to the partial derivative of the quantity supplied with respect to own price, consider the partial derivatives of the supply curve with respect to the prices of the inputs

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and

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These partial derivatives isolate the effects of the input prices on quantity supplied

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We expect that quantity supplied will decrease if input prices rise (and will increase if input prices fall), all else equal. Therefore, our expectation is that

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and

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For our example, we find that this is true:

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and

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Comparative Statics

By extending our supply and demand framework to one of many variables, we can now model the effects on equilibrium price and quantity of a change in variables other than a good's own price. This type of before and after modeling of an equilibrium is often called *comparative statics*. As a starting point, consider the equilibrium condition (quantity demanded equals quantity supplied) with variables in addition to the good's own price included. We can then solve for a new equilibrium after a change in the value of an additional variable, and solve for the new equilibrium using the algebraic methods in Chapter 2. An example is provided in the following Figure It Out.

2A.1 figure it out

Let's continue the example from Figure It Out 2.3 in the textbook. As in the text, suppose that the supply of orange juice is represented by

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where quantity is measured in pints and price is measured in cents per pint.

a. Now suppose that the demand for orange juice is

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   where *I* is income. What are the current equilibrium price and quantity if income is $100,000?
b. Suppose that income increases to $125,000. What is the new equation for the demand of orange juice?
c. What will be the new equilibrium price and quantity of orange juice after the income increase?
d. Is orange juice a normal or an inferior good? Answer the question using a partial derivative and its interpretation.

Solution:

a. The original equilibrium price and quantity are found by substituting income into the demand relationship and then setting this equal to the supply side:

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   Note that the demand side is equivalent to the demand curve, as given in the problem in the text.

   Setting quantity demanded equal to quantity supplied, we get

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This corresponds to $1 since price is in cents.

To obtain the quantity, we can substitute into the supply or demand equations (or both to check):

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This corresponds to 4,000 pints.

b. Now,
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Note that the increase in income decreases quantity demanded at each price and results in a parallel shift of the demand curve downward and to the left.

c. Setting quantity demanded equal to quantity supplied yields

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To get quantity, we can substitute *P* into the supply or demand equation (or both to check):

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Thus, price is now $0.90 and quantity is 3,600 pints.

Note that as income increases, both quantity and price fall.

d. Orange juice is an inferior good here because
Error parsing MathML: error on line 1 at column 1679: Opening and ending tag mismatch: img line 0 and annotation-xml
and therefore quantity demanded decreases with income. This is consistent with the directions of the quantity and price changes identified above.

Figure 2.10 in the text examines how an equal magnitude shift of the demand curve (and supply curve) affects equilibrium price and quantity differently depending on the relative steepness or flatness of the supply curve (and demand curve). Note that for the example in the Figure It Out above, the supply curve is relatively flat. Consider instead a supply curve of
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which is steeper. Note that despite having a different slope and intercept, this curve has the property of going through the original equilibrium because

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Now consider the effects of an increase in income to $125,000. Setting the new demand curve as in the Figure It Out example equal to this alternate supply, we find that
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To obtain the quantity, we can substitute into the supply or demand equations (or both to check). From demand,
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The same income increase therefore leads to a lower equilibrium price and higher equilibrium quantity
Error parsing MathML: error on line 1 at column 1184: Opening and ending tag mismatch: img line 0 and a
when supply is steeper, and a higher equilibrium price and lower quantity
Error parsing MathML: error on line 1 at column 1184: Opening and ending tag mismatch: img line 0 and a
when supply is flatter. Thus, the price decrease is greater in the case of steep supply, and the quantity decrease is greater in the case of flat supply. This is the same pattern identified in the discussion around Figure 2.10. (Note, however, that the figure illustrates a rightward shift of demand, as opposed to the leftward one in this problem.) The methods here can be used to extend beyond the case of just one curve shifting, to cases in which both supply and demand simultaneously shift, resulting in an even wider range of possible outcomes.

We can also use calculus to examine comparative statics for marginal changes in variables other than price. As an example, let's look at the case of a change in income. The equilibrium condition expressed as a function of income is
Error parsing MathML: error on line 1 at column 2658: Opening and ending tag mismatch: img line 0 and a
We want to know how price and quantity change with income, but we don't want to hold everything else constant in the background (i.e., we want to analyze the effects of an income change on actual equilibrium price and quantity). To start, we can differentiate the equilibrium with respect to income[4]:

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Rearranging this equation, we can see that

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We can then solve for the derivative of price with respect to income:

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To make this more concrete, let’s reconsider the case in the previous Figure It Out in which
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and
Error parsing MathML: error on line 1 at column 930: Opening and ending tag mismatch: img line 0 and an
For that example,

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This means that the $25,000 increase in income in that example lowers the equilibrium price by
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Likewise, the change in quantity is
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so the $25,000 increase in income lowers equilibrium quantity by
Error parsing MathML: error on line 1 at column 1308: Opening and ending tag mismatch: img line 0 and a
These are the same changes in the price and quantity of lemonade found in the Figure It Out example.

Elasticities

Note that the effect of an income change on equilibrium quantity is different from the effect of an income change on quantity demanded (or likewise on quantity supplied). For the latter, we can use calculus to calculate a partial derivative, as we did in part (d) of the Figure It Out exercise. The partial derivative
Error parsing MathML: error on line 1 at column 1391: Opening and ending tag mismatch: img line 0 and a
for example, lets us know that for a very small increase in income—holding all else equal—quantity demanded changes by
Error parsing MathML: error on line 1 at column 1330: Opening and ending tag mismatch: img line 0 and a
units. These units, however, are difficult to interpret. As a result, economists turn to another calculation that allows for easier interpretation: elasticities.

In calculus terms, elasticities are partial derivatives. Consider the price elasticity of demand, which can be written as

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where
Error parsing MathML: error on line 1 at column 707: Opening and ending tag mismatch: img line 0 and an
is quantity demanded and *P* is price.

Note the similarities with the equation for the income elasticity of demand. The price elasticity of supply can be written as
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Similarly, the income elasticity of demand can be written as
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where *I* is income, and the cross-price elasticity of demand can be written using subscripts as in the chapter as
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where
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is the price of a related good (e.g., a substitute or a complement) to good *X*.

Total Expenditure and the Price Elasticity of Demand

We can also use calculus to derive the relationship between (1) total expenditure changes from price changes and (2) the elasticity of demand. Total expenditure, and likewise total revenue, can be expressed as
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where quantity is expressed as a function of price. We can therefore think about maximizing this function with respect to *P*:

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We can find the first-order condition by taking the derivative of the total expenditure function with respect to *P* and then setting this derivative equal to zero. The first-order condition[5] therefore is

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Rearranging, we can see that

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Note that the left side of this equality is simply the price elasticity of demand[6], so
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This means that expenditure is maximized when demand is unit-elastic.[7] When demand is inelastic (when the price elasticity of demand is less than 1 in absolute value), consumer expenditure increases with a price increase. Expressed with calculus, this means that for inelastic demand,
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This can be shown by examining the case that
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Rearranging this,
Error parsing MathML: error on line 1 at column 2303: Opening and ending tag mismatch: img line 0 and a
Dividing both sides by
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we see that
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Because
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is a negative number for a downward-sloping demand curve, this condition corresponds to inelastic demand.

Similarly, for elastic demand (when the price elasticity of demand is greater than 1 in absolute value), consumer expenditure decreases for a price increase, meaning that
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Therefore, only in the case of unit-elastic demand (when the price elasticity of demand is exactly 1 in absolute value) would consumer expenditure be at a maximum (as it should be given the optimization exercise outlined above)!

2A.2 figure it out

Suppose that the inverse demand curve for hospital scrubs in bright floral prints can be expressed as
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where price is in dollars and quantity is in thousand sets (top and bottom). What is the price elasticity of demand at a quantity of 25,000 sets?

Solution:

Note that this is a nonlinear demand curve since quantity *Q* is raised to a power other than 1 and therefore the relationship between price and quantity is nonlinear. As a tool, calculus provides a way to calculate the price elasticity of demand for this equation at a given quantity. First, note that when quantity is 25,000 sets,
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and therefore a set of floral scrubs costs $30. The price elasticity of demand formula is
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Using the demand curve equation, we can see that
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At a quantity of 25,000 sets, this value is
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Making the appropriate substitutions, we find that
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Sets of floral hospital scrubs therefore are price-elastic, because hospital workers may switch to other patterns when price increases. Notice that this method can be used similarly for income and cross-price elasticities in situations when demand is nonlinear and for supply elasticities when supply is nonlinear.

Problems

1. Suppose that the supply of specialty workstation laptops is represented by
   Error parsing MathML: error on line 1 at column 1088: Opening and ending tag mismatch: img line
   where price is measured in dollars and quantity is measured in units.
   a. Now suppose that the demand for the laptops is
      Error parsing MathML: error on line 1 at column 1184: Opening and ending tag mismatch: img
      where *I* is income. What are the current equilibrium price and quantity if income is $100,000?
   b. Suppose that income falls to $80,000. What is the new equation for the demand?

c. What will be the new equilibrium price and quantity after the income decrease?

d. Is the laptop workstation a normal or an inferior good? Answer the question using a partial derivative.

2. Suppose that the supply of a flat panel TV stand is represented by
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where *P* is the price of the stand and
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line
is the price of the hardware needed to hold the stand together. All prices are in dollars and quantity is in units. Assume that the current hardware price is $5.

   a. Suppose that the demand for the TV stand is
   Error parsing MathML: error on line 1 at column 1232: Opening and ending tag mismatch: img
   where *P* is the price and *I* is a representative household's income. What are the current equilibrium price and quantity if income is $1,000?

   b. Suppose that income falls to $800. What is the new equation for the demand for TV stands as a function of price *P*? Does this correspond to an increase or decrease in the demand for the TV stands? Does the demand curve shift to the left or right?

   c. Suppose that the price of the hardware increases to $6. What is the new equation for the supply of TV stands as a function of price *P*? Does this correspond to an increase or decrease in supply? Does the supply curve shift to the left or right?

   d. What will be the new equilibrium price and quantity of the TV stand after the changes in supply and demand [after all changes in parts (b) and (c)]?

3. From the original setup in Problem 2, suppose that the quantity supplied of flat panel TV stands is represented by
Error parsing MathML: error on line 1 at column 1351: Opening and ending tag mismatch: img line
where *P* is the price of the stand and
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line
is the price of hardware inputs, and that quantity demanded is
Error parsing MathML: error on line 1 at column 1220: Opening and ending tag mismatch: img line
where *I* is income. Assume that at the equilibrium, income is $1,000 and the hardware price is $5.

   a. Calculate the income elasticity of demand using calculus.

   b. Calculate the input elasticity of supply using calculus. (*Hint*: Think of cross-price elasticities on the demand side as being analogous to "input" elasticities on the supply side.)

4. Suppose that the inverse demand curve for a dinner-for-two special at a small local restaurant can be expressed as
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where price is expressed in dollars and quantity in number of specials. What is the price elasticity of demand when 40 specials are purchased?

Chapter 3

Using Supply and Demand to Analyze Markets

- **3.1 Consumer and Producer Surplus:** Who Benefits in a Market?
- **3.2 Price Regulations**
- **3.3 Quantity Regulations**
- **3.4 Taxes**
- **3.5 Subsidies**
- **3.6 Conclusion**
- **Appendix 3A The Calculus of Consumer and Producer Surplus**

Governments often enact policies that affect how markets work. The purpose of these policies can be to serve a particular constituency, to raise necessary tax revenue, or (as we'll see in Chapter 17) to correct a market failure. For example, every time gas prices rise above a level that the public will tolerate, some politicians call for a cap on gas prices (or at least an investigation). Opinion polls conducted at such times suggest people like that idea. Are they right? Whether changes in market conditions are the result of government market interventions or changes in any of the many factors that affect supply, demand, or both, we can use supply and demand analysis to figure out not only what happens to price and quantity, but also who benefits, who loses, and by how much.

In Chapter 2, we introduced supply and demand analysis. We learned about the economic decisions that supply and demand curves embody, and we defined what it means for a market to be in equilibrium. Now we put those tools to work. We show how to measure the total benefits that consumers and producers gain in any given market, and how these benefits change when supply or demand shifts. We also show how various government interventions into markets affect the well-being of consumers and producers.

3.1 Consumer and Producer Surplus: Who Benefits in a Market?

To understand the market impact of any policy, we need a way to measure the benefits consumers and producers obtain from participating in that market. Economists measure these benefits using the concepts of consumer and producer surplus.

Consumer Surplus

Consumer surplus is the difference between the price consumers would be willing to pay for a good (as measured by the height of their demand curves) and the price they actually have to pay. Consumer surplus is usually measured as an amount of money. Suppose someone with $1,000 in their pocket is lost in the desert and extremely thirsty. They stumble upon a convenience store, where they spot a bottle of water for sale. This individual would be willing to pay their entire $1,000 for it. Applying the concept of elasticity from Chapter 2, we can say their demand for a drink is almost perfectly inelastic: They will demand the one bottle of water almost regardless of its price. Let's say the store is asking $1 for the bottle of water. This thirsty consumer was willing to pay $1,000 for the water but only had to pay the $1 market price. After the transaction, they have their drink *and* $999 left in their pocket. That $999—the difference between what they were willing to pay and what they actually paid—is their consumer surplus.

consumer surplus
The difference between the price consumers would be willing to pay for a good (as measured by the height of their demand curves) and the price they actually have to pay.

We can take this one-person example and extend the consumer surplus to the demand curve for an entire market. For example, let's return to Pike Place Market but now consider the market for Honeycrisp apples. The market demand curve in **Figure 3.1** tells us how many pounds of apples consumers are willing to buy at any given price. If every point along the market demand curve represents a different person's willingness to pay for a pound of apples, we can measure each person's consumer surplus just as we did for our thirsty consumer.

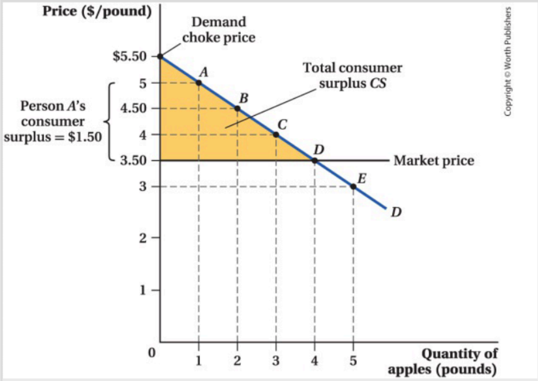

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Figure 3.1 Consumer Surplus: The Difference between the Amount Consumers Are Willing to Pay and the Amount They Have to Pay

The market demand curve shows how many pounds of apples consumers are willing to buy at a given price. The consumer at point *A* is willing to pay $5 for 1 pound of apples; if we assume a market price of $3.50, this person has a consumer surplus of $1.50. Similarly, at the market price of $3.50, consumers at points *B and C* have consumer surpluses of $1 and $0.50, respectively. The person at point *D* is willing to pay the market price of $3.50 a pound, and thus, no consumer surplus exists for this individual.[1] The consumer at point *E* does not purchase any apples. The total consumer surplus, the total gains for each individual who buys apples—person *A*, person *B*, and so on—is the area under the demand curve and above the price, represented by the area of the shaded triangle *CS*. The base of the consumer surplus triangle is the quantity sold. The height of the triangle is the difference between the market price ($3.50) and the *demand choke price* ($5.50 per pound), the price at which quantity demanded is reduced to zero.[2]

In this Pike Place Market apple example, the demand curve represents a collection of consumers, each with a different willingness to pay for the good. Those with a high willingness to pay are located at the upper left portion of the curve; those with a lower willingness to pay are down and to the right along the curve. The same logic also applies to an individual's demand curve, which reflects their declining willingness to pay for each additional unit of the good. For instance, an apple buyer might be willing to pay $5 for the first pound of apples they buy, but only $4 for the second pound, and $3.50 for the third pound (maybe they have limited ability to store them, or they just get tired of eating apples after a while). If the market price is $3.50 per pound, they will buy 3 pounds of apples. Their consumer surplus will be $1.50 for the first pound, $0.50 for the second, and zero for the third, a total of $2. Doing this calculation for all apple buyers and adding up everyone's consumer surpluses will give the total consumer surplus of the same type shown in the triangular area in Figure 3.1.

Producer Surplus

Just as consumers gain surplus from engaging in market transactions, so do producers. **Producer surplus** is the difference between the price producers actually receive for their goods and the cost of producing them (measured by the height of the supply curve). The supply curve in the Pike Place apple market (**Figure 3.2**) tells us how many pounds of apples producers are willing to sell at any given price, and as we discussed in Chapter 2 and will explain in more detail in Chapters 7 and 8, this comes from the costs of producing the goods.

producer surplus
The difference between the price producers actually receive for their goods and the cost of producing them (measured by the height of the supply curve).

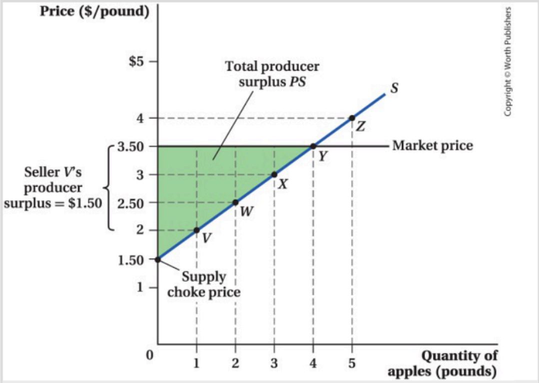

Figure 3.2 Producer Surplus: The Difference between the Price Producers Receive for Their Goods and the Cost of Producing Them

If we think of every point on the supply curve as representing a different apple seller, we see that Firm *V* would be willing to supply apples at a price of $2 per pound. Because it can sell apples at the market price of $3.50, however, it receives a producer surplus of $1.50.[3] Firm *W* is willing to sell apples for $2.50 per pound and so receives $1 of producer surplus, while Firm *X* receives $0.50 of producer surplus. Firm *Y*, which is only willing to sell a pound of apples for $3.50, receives no surplus. Firm *Z* is shut out of the market; the market price of $3.50 per pound is less than its willingness to sell ($4).

The total producer surplus for the entire market is the sum of the producer surplus for every seller along the supply curve. In this example with a linear supply curve, the sum equals the triangle above the supply curve and below the price, the area of the shaded triangle *PS*. The base of the triangle is the quantity sold. The height of the triangle is the difference between the market price ($3.50) and the *supply choke price*, the price at which quantity supplied equals zero. Here, the supply choke price is $1.50 per pound; no seller is willing to sell apples below that price.

➡ Appendix 3A, *The Calculus of Consumer and Producer Surplus*, uses integration to find consumer and producer surplus.

The supply curve in Figure 3.2 represents a collection of producers that differ in their willingness to sell. The same logic applies to an individual producer's supply curve in cases where the firm's cost of producing additional output rises with its output. In these cases, the firm must be paid more to sell additional units.[4] The firm's producer surplus is the sum of the differences between the market price and the minimum price the firm would need to receive to be willing to sell each unit.

figure it out 3.1

The demand and supply curves for candy bars in a midwestern city are given by

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where Q is measured in thousands of candy bars per day and P in dollars per candy bar.

a. Find the equilibrium price and quantity.
b. Calculate the consumer and producer surplus at the equilibrium price.

Solution:

a. Equilibrium occurs where Error parsing MathML: error on line 1 at column 1058: Opening and ending tag mismatch: img line 0 and annotation-xml. Therefore, we can solve for equilibrium by equating the demand and supply curves:
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   Therefore, the equilibrium price of a candy bar is \$0.75. To find the equilibrium quantity, we need to plug the equilibrium price into either the demand curve or the supply curve:

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   Remember that Q is measured in terms of thousands of candy bars per day, so the equilibrium quantity is 137,000 bars per day.
b. To calculate consumer and producer surplus, it is easiest to use a graph. First, we need to plot the demand and supply curves. For each curve, we can identify two points. The first point is the equilibrium, given by the combination of equilibrium price (\$0.75) and equilibrium quantity (137). The second point we can identify is the choke price. The choke prices for demand and supply can be determined by setting Error parsing MathML: error on line 1 at column 707: Opening and ending tag mismatch: img line 0 and annotation-xml and Error parsing MathML: error on line 1 at column 707: Opening and ending tag mismatch: img line 0 and annotation-xml equal to zero and solving for P:

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So, the demand choke price is \$7.60 and the supply choke price is \$0.02.

The demand and supply curves are graphed in the figure below. Consumer surplus is the area below demand and above the price (area A). Its area can be calculated as

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Producer surplus is the area below price and above supply (area B):

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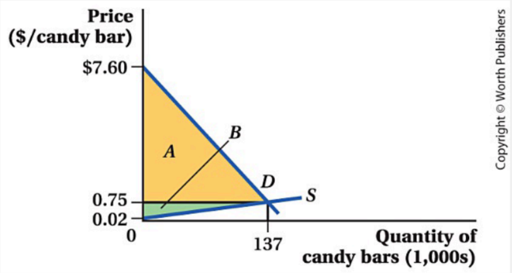

Application: The Value of Innovation

Equipped with the concepts of consumer and producer surplus, we can analyze one of the most important issues in economics—the introduction of new products. Economists emphasize the importance of innovation and new goods in raising a society's standard of living. In any discussion of the value of innovation, we need a way to compute how much benefit a new product gives to consumers.

A simple suggestion for valuing a new product would be to just add up what people paid for it. However, that's wrong. Many consumers value the product at much more than the price they paid to get it. Consumer surplus measures the full benefit of the new product because it tells us how much consumers value the product *over and above* the price they pay.

A key factor in determining the amount of potential consumer surplus in a market for a new good is the steepness of the demand curve: All else equal, the steeper it is, the bigger the consumer surplus. That's because steep demand curves mean that at least some consumers (those on the upper-left-hand part of the demand curve) have very high willingness to pay for the good. You can see this on a price–quantity demand curve diagram. First, draw a horizontal line representing an equilibrium market price. Next, draw various demand curves with different slopes that intersect this price at the same point—that is, so the equilibrium quantity demanded is the same. You will see that the consumer surplus triangles are larger for steeper demand curves.

Let's look at eyeglasses as an example. Economist Joel Mokyr explained in his book *The Lever of Riches* that the invention of eyeglasses around the year 1280 allowed craftsmen to do detailed work for decades longer than they could before. If we think of glasses as a "new technology" circa 1280, we can visualize what the demand curve for glasses might have looked like. Because many people in 1280 would be quite blind without glasses, the demand curve was probably very steep—there was a set of individuals with a very high willingness to pay for glasses, and their demand wasn't particularly sensitive to prices. This steepness of the demand curve probably remained stable for several centuries, until contact lenses became widely available in the latter half of the twentieth century.

In Chapter 2, we learned that readily available substitute goods are likely to make demand more elastic. This is true of glasses, too: When contact lenses became available, the demand for glasses became more price elastic. How would this change in elasticity affect the consumer surplus people get from the existence of eyeglasses? **Figure 3.3** illustrates the answer.

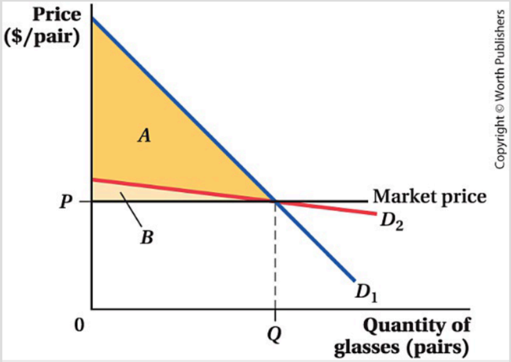

Figure 3.3 Consumer Surplus and the Elasticity of Demand

Before contact lenses were available, consumer surplus was large because the demand for glasses
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was inelastic—if you wanted to see better, glasses were the only game in town. The consumer surplus was the area above the price and below
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml,
or area
Error parsing MathML: error on line 1 at column 683: Opening and ending tag mismatch: img line 0 and annotation-xml.
Many people would be willing to buy glasses even if the price were much higher than *P*. (That's what having an inelastic demand means.)

When contact lenses became available, the demand for glasses became much more elastic, as shown by curve
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Even if just as many people bought glasses at the equilibrium price as before, a sharp rise in the price of glasses would have caused many people to stop buying them because now they had an alternative. The figure shows that the consumer surplus from glasses declines after contacts come on the market. The area below the new, flatter demand curve and above the price is only area *B*.

Remember that consumer surplus depends on the *most* that people would be willing to pay for the product. That maximum price goes down if alternatives are available. When alternative methods of vision correction are available, glasses are just another option rather than a virtual necessity, and the consumer surplus associated with them falls. If you're concerned this example implies that innovation destroys surplus, remember that the substitute goods create surpluses of their own. They have their own demand curves, and the areas under those curves and above the substitute goods' prices are also consumer surplus. For example, while the invention of contact lenses reduces the consumer surplus provided by glasses, it creates a lot of surplus in the new contact lens market.

The Distribution of Gains and Losses from Changes in Market Conditions

One nice thing about our definitions of producer and consumer surplus is that we can analyze the impact of any changes on either side of a market in a way that builds on the analysis we started in Chapter 2. There, we learned how shocks to supply and demand affect prices, quantity demanded, and quantity supplied. We can also show how these shocks affect the benefits producers and consumers receive in a market. **Figure 3.4** shows the initial supply and demand in the market for doughnuts. We see that at the market price
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the doughnuts buyers' benefit from buying doughnuts is greater than the price they

pay for the doughnuts (reflected in the consumer surplus area

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Similarly, the doughnut makers' benefit from making the doughnuts is greater than the price at which they sell the doughnuts (reflected in the producer surplus area

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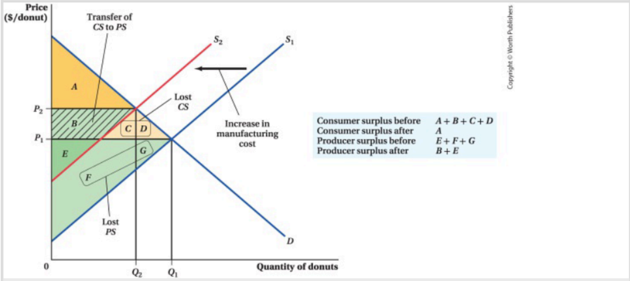

Figure 3.4 Changes in Surplus from a Supply Shift

Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml and *D* are the initial supply and demand for doughnuts. At market price Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml, consumer surplus is the area Error parsing MathML: error on line 1 at column 907: Opening and ending tag mismatch: img line 0 and annotation-xml, and producer surplus is the area Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and annotation-xml.

An increase in the manufacturing cost of doughnuts causes the supply curve to shift leftward from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml. At the new equilibrium price Error parsing MathML: error on line 1 at column 949: Opening and ending tag mismatch: img line 0 and annotation-xml and quantity Error parsing MathML: error on line 1 at column 949: Opening and ending tag mismatch: img line 0 and annotation-xml, consumer surplus has been reduced to the area *A*. The new producer surplus is shown by Error parsing MathML: error on line 1 at column 683: Opening and ending tag mismatch: img line 0 and annotation-xml. The net effect of the inward supply shift on producer surplus is negative because downward-sloping demand means the price will rise less than the increase in cost.

Now let's suppose a severe drought in Thailand, the world's second largest exporter of raw sugar, has driven up the price of sugar worldwide. When this "sugar shock" hits, the cost of making doughnuts rises and suppliers are no longer willing to supply as many doughnuts at any given price. The supply of doughnuts falls, as reflected in the inward shift of the doughnut supply curve from

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to

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In response to the sugar shock, the equilibrium price of doughnuts rises to

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and the quantity of doughnuts bought and sold in the doughnut market falls to

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These changes affect both consumer and producer surplus. The higher equilibrium price and lower equilibrium quantity both act to reduce consumer surplus. Compared to triangle

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in Figure 3.4, triangle *A* is much smaller. For producer surplus, the lower equilibrium quantity that results from the supply shift reduces it, but this reduction is partially counteracted by the higher price. These opposing effects can be seen in Figure 3.4. Some of the producer surplus before the shift—specifically, the space

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between the old and new supply curve and below the demand curve—is lost. But the price increase shifts some of what was consumer surplus to producer surplus; this is area *B*. Because the equilibrium price rises less than the increase in cost (a consequence of downward-sloping demand), however, it must be that the increase in producer surplus from a higher price is less than the surplus lost due to higher costs. Therefore, the net effect on producer surplus of the inward supply shift is negative. These effects on consumer and producer surplus are reversed for outward supply shifts.

We can do a similar analysis for the effects of demand shifts. An inward shift in demand leads to a lower equilibrium price and quantity, both of which reduce *producer* surplus. The impact on consumer surplus, however, has opposing effects. Having a smaller equilibrium quantity reduces consumer surplus, but this reduction is counteracted by the drop in price. Similar to the supply shift case above (but in the opposite direction), the inward demand shift transfers to consumers part of what was producer surplus. We see these effects in the application that follows.

Application: Toxic Algae in Florida

Periodically, warm water temperatures and excess agricultural runoff will cause a bloom of toxic algae, known as a “red tide” (or “green slime”), to form along Florida’s Gulf coast. As water temperatures have risen, the algae blooms have become more frequent; they sometimes stretch hundreds of miles and persist for multiple months. The smell is awful, and the effects are harmful. When a red tide occurs, lifeguards often must wear respirators to prevent lung infections, and masses of fish die and wash up on the shores. Thousands of tourists cancel their planned vacations on the Gulf.

Joe Raedle/Getty Images

A toxic algae bloom in Florida.

When the governor of Florida declares the red tide an official natural disaster, Florida’s Economic Development Committee will try to compensate merchants for the damage done by the disaster. They then design surveys to analyze the issue. What they’re trying to compute is, simply put, the loss in producer surplus.

To compute the loss, they ought to estimate a supply and a demand curve, and then contemplate any shift in demand. Such a shift is illustrated in **Figure 3.5**. Prices and quantities decrease in response to a red tide event—just as the model suggests. Before the red tide, producer surplus is the area below the equilibrium price and above the supply curve, or
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in the graph. After the tide, the area would just be *C*. The amount of producer surplus lost from the drop in demand would be *A* and *B*. The committee can figure that out with the information on how much price and quantity changed. Note that this involves not just the simple calculation of lost revenue, which would be
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They would also need to subtract the costs the producers saved by not having to produce such additional goods, which is the area under the supply curve between
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and
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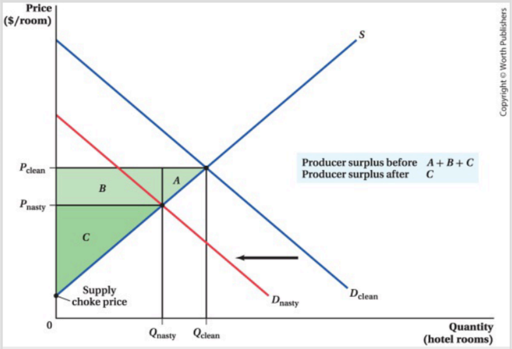

Figure 3.5 “Red Tide” Damage in Florida

After a toxic algae bloom in Florida, the demand curve for hotel rooms from people visiting the Gulf Coast shifts inward, from
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to
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During the time when the Gulf’s waters are clean, the equilibrium hotel room price and quantity are
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and
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respectively, and the producer surplus is the total shaded area,
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Once the waters become nasty, the equilibrium price and quantity fall to
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and
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and the producer surplus is reduced to the area *C*. The area
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represents the loss in producer surplus to the local hotels.

figure it out 3.2

A local tire market is represented by the following equations and in the diagram offered below:

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where *Q* is the number of tires sold weekly and *P* is the price per tire. The equilibrium price is $100 per tire, and 700 tires are sold each week.

Suppose an improvement in the technology of tire production makes them cheaper to produce so that sellers are willing to sell more tires at every price. Specifically, suppose that quantity supplied rises by 200 at each price.

a. What is the new supply curve?
b. What are the new equilibrium price and quantity?
c. What happens to consumer and producer surplus as a result of this change?

Solution:

a. Quantity supplied rises by 200 units at every price, so we simply add 200 to the equation for
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b. The new equilibrium occurs where
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   We can find the equilibrium quantity by substituting the equilibrium price into either the supply or demand equation (or both):

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   The new equilibrium quantity is 825 tires per week. Notice that because supply increased, the equilibrium price fell and the equilibrium quantity rose just as we would predict.
c. The easiest way to determine the changes in consumer and producer surplus is to use a graph such as the one shown here. To calculate all the areas involved, we need to make sure we calculate the demand choke price and the supply choke prices before and after the increase in supply.

   The demand choke price is the price at which quantity demanded is zero:

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   The demand choke price is $128.

   The supply choke price is the price at which quantity supplied is zero. Because supply is shifting, we need to calculate the supply choke price for each supply curve:

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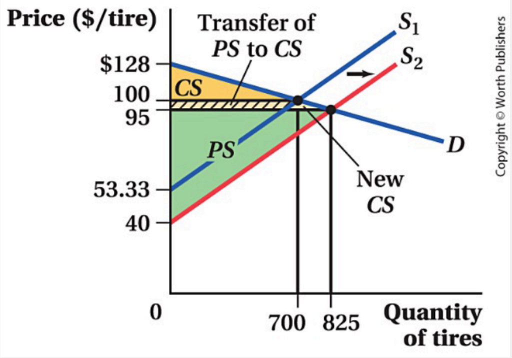
   The initial supply choke price is $53.33 but falls to $40 when supply increases.

With the choke prices and the two equilibrium price and quantity combinations, we can draw the supply and demand diagram.



Consumer surplus: The initial consumer surplus is the area of the triangle below the demand curve but above the initial equilibrium price ($100):

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The new consumer surplus is the area of the triangle below the demand curve and above the new equilibrium price ($95):

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So, after the outward shift in supply, consumer surplus rises by $3,812.50.

Producer surplus: The initial producer surplus is the area of the triangle below the initial equilibrium price and above the initial supply curve
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The new producer surplus is the area of the triangle below the new equilibrium price and above the new supply curve
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The increase in supply also led to a rise in producer surplus by $6,353.

3.2 Price Regulations

Politicians call regularly for price ceilings on products whose prices have risen a lot. In this section, we explore the effects of direct government interventions in market pricing. We look at both regulations that set maximum prices (like a gas price ceiling) and minimum prices (like a price floor such as a minimum wage).

Price Ceilings

A **price ceiling** establishes the highest price that can be paid legally for a good or service. At various times, regulations have set price ceilings for cable television, auto insurance, flood insurance, electricity, telephone rates, gasoline, prescription drugs, apartments, food products, and many other goods.

price ceiling
The highest price that can be paid legally for a good or service.

If the price ceiling is above market equilibrium price, it is nonbinding and will not hinder the free-market outcome. The more interesting case is when the price ceiling is lower than market equilibrium.

Suppose the city council of a college town passes a pizza price control regulation. With the intent of helping out the college's financially strapped students, the city council says no pizzeria can charge more than $8 for a pizza. Let's say the demand curve for pizzas in a month during the school year is described by the equation
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The cheaper pizzas get, the more students will eat them, so the demand curve slopes downward. If the price were zero, 20,000 pizzas would be sold per month (the college in town isn't that big, and there are only so many meals a person can eat). The demand choke price is $20 per pizza—if the price were $20 per pizza, no pizzas would be sold.

Let's say the supply of pizzas is given by
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Supply slopes upward because when prices are higher, the local pizzerias make more pizzas. If the price is below $5, they make no pizzas. For each $1 increase in the price of a pizza after that, an additional 2,000 pizzas per month would be supplied.

Figure 3.6 graphs the supply and demand curves described by these two equations. The free-market equilibrium is at point *w*; that is, before price controls, the equilibrium price for a pizza is $10, and at that price, 10,000 pizzas are supplied and demanded. Given these baseline market conditions, we can study the impact of the price ceiling using the graph or the equations. Let's start with the graph.

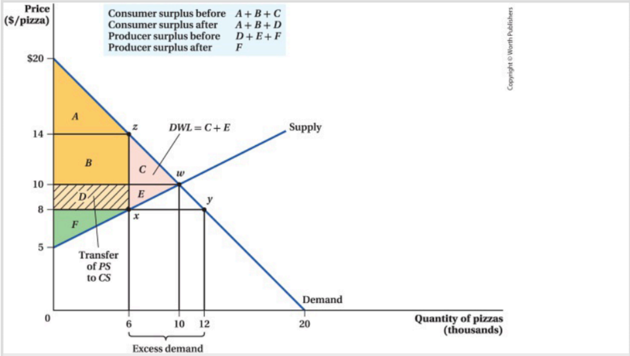

Figure 3.6 The Effects of a Price Ceiling

A price ceiling affects both producer and consumer surpluses. Before price controls in the pizza market, consumers pay $10 per pizza, and producers supply 10,000 pizzas per week at the equilibrium point *w*. Consumer surplus is the triangle Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and annotation-xml, and producer surplus is Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and annotation-xml. At the $8 price ceiling, pizzerias are only willing to supply 6,000 pizzas (point *x*), but consumers demand 12,000 pizzas (point *y*), creating excess demand. Because pizzerias are now selling fewer pizzas at a lower price, producer surplus is reduced to area *F*. The new consumer surplus is the area Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and annotation-xml, and the net gain to consumers is Error parsing MathML: error on line 1 at column 685: Opening and ending tag mismatch: img line 0 and annotation-xml. The shaded area Error parsing MathML: error on line 1 at column 683: Opening and ending tag mismatch: img line 0 and annotation-xml is the deadweight loss created by the price ceiling.

Graphical Analysis

Before any price controls, the consumer surplus for pizza-eating students is given by the area below the demand curve and above the $10 free-market price, Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and an

The producer surplus is the area above the supply curve but below the price, Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and an

When the city council implements the price control regulation, the highest price the pizzerias can charge is $8 per pizza, which is less than the market-clearing price of $10. At $8, students demand a total of 12,000 pizzas (point *y*). This quantity demanded is larger than the 10,000 pizzas demanded at the free-market equilibrium because the price ceiling price is lower than the free-market price. At an $8 price, however, pizzerias are only willing to supply 6,000 pizzas (point *x*). That is, there is **excess demand**: The difference between the quantity demanded and the quantity supplied at a price ceiling. There will be a large number of students frustrated that they cannot buy the number of pizzas they would like at the price ceiling.

excess demand
The difference between the quantity demanded and the quantity supplied at a price ceiling.

Now consider how the price ceiling affects consumer and producer surplus. It's clear that the pizzerias are worse off. In the free market, they would have sold more pizzas (10,000 versus 6,000) at a higher price ($10 versus $8). The producer surplus after the price control law is everything below the capped price and above the supply curve; producer surplus shrinks from area Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and an to area *F*.

The law was passed to benefit students by lowering pizza prices. But we can't actually say for sure whether they are better off as a result.[5] The consumer surplus with the price ceiling is the area below the demand curve and above the price, area

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The consumer surplus now includes area *D* because imposing price controls shifted that area from being part of producer surplus to being part of consumer surplus. We call area *D* a **transfer**, surplus that moves from producer to consumer, or vice versa, as a result of a price regulation.

transfer
Surplus that moves from producer to consumer, or vice versa, as a result of a price regulation.

However, fewer pizzas are bought after the price cap law, resulting in consumers losing area *C*. Therefore, the net impact of the price cap on consumers depends on the relative sizes of the surplus transferred from the producers (area *D*) and loss reflected in area *C*. For those students who are able to buy the 6,000 pizzas in a month at a price that is $2 lower than they did before the law was enacted, life is good. They get the area *D* transfer. But for the students who would have enjoyed 4,000 more pizzas in the free market that they can no longer buy, life is now a hungry proposition.

The producer surplus and consumer surplus represented by areas *C* and *E* have disappeared because of the price ceiling. No one receives these surpluses anymore. Their combined areas are known as a **deadweight loss (DWL)**, which is the difference between the maximum total surplus that consumers and producers could gain from a market and the combined gains they actually reap after a price regulation, and it reflects the inefficiency of the price ceiling. It's called a deadweight loss because it represents the loss of a set of mutually beneficial, surplus-generating transactions (pizza purchases, in this case) that would have occurred in an unregulated market with a customer who was willing to buy and a producer who was willing to sell at the market price. Area *C* is the deadweight loss suffered by consumers; area *E* is lost by producers.

deadweight loss (DWL)
The difference between the maximum total surplus that consumers and producers could gain from a market and the combined gains they actually reap after a price regulation.

It's important to understand that there is a loss in consumer surplus even though the students get to keep the money they're not spending on pizza. The people missing out on the 4,000 pizzas after the price control law don't want to save the $10—they want the pizza! There is a loss of consumer surplus because the pizzas those students would have gotten for $10 would be worth *more* than $10 to them. People who buy are on the part of the demand curve that is above the market price (except that individual right *at* the market price); their willingness to pay is greater than the price they have to pay. The price control results in their losing that difference.

Some producer surplus also becomes deadweight loss as a result of the price ceiling. There are pizzerias that would be willing to sell pizzas for more than $8 but less than the $10 equilibrium price. Once the $8 price ceiling is in place, pizzerias will pull 4,000 pizzas off the market because $8 is not enough to cover their costs of making those extra pizzas. So, both students and pizzerias benefited from transactions that took place before the price control; once the price ceiling is imposed, however, some of those transactions no longer take place and they lose those benefits.

Analysis Using Equations

Now compare the free and regulated markets for pizzas using the supply and demand equations we described earlier. To determine the free-market equilibrium using the equations, we set quantity supplied equal to quantity demanded and solve for the market clearing price *P*:

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Plugging that price back into either the supply or demand equation gives an equilibrium quantity of 10,000 pizzas:

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The consumer surplus in the free market is the

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The area of that triangle is

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The demand choke price is the price at which

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In this case,

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The consumer surplus triangle is

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(Remember that quantities are measured in pizzas per month, so the consumer surplus is measured in dollars per month.)

The producer surplus is the triangle

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in the graph. The area of that triangle is

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The supply choke price is the price at which quantity supplied is zero:

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Plugging this price into the equation for producer surplus, we find

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Now consider the impact of the price ceiling. The price of a pizza cannot rise to $10 as it did in the free market. The highest it can go is $8. We saw in the graphical analysis that this policy led to excess demand, the difference between the quantity demanded and the quantity supplied at the price ceiling

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The excess demand is

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or 6,000 pizzas per month. This means that there are students ringing pizzerias' phones off the hook trying to order more pizzas, but whose orders the pizzerias won't be willing to fill at the new market price.

Next, we compute the consumer and producer surpluses after the price control is imposed. Producer surplus is area *F*:

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which is just over one-third of the $25,000 of producer surplus pizzerias were making before the price ceiling. It is no wonder that producers fight against laws like this one.

The consumer surplus is now areas

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An easy way to figure out the value for this surplus is to add the area of triangle *A* to the area of the rectangles *B* and *D*. Triangle *A* has an area of:

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where the price at point *z* is the price at which quantity demanded equals the new quantity supplied of 6,000 pizzas. To determine this price, set

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and solve for the price:

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This means that, if the price of a pizza were actually $14, exactly 6,000 pizzas would be demanded. With this value for the price at point *z*, we can now calculate:

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The area of rectangle *B* is

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and the area of rectangle *D* (the transfer) is

Error parsing MathML: error on line 57 at column 34: Opening and ending tag mismatch: img line 0 and an

Adding these three areas, we find that total consumer surplus after the pizza price ceiling is
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per month.

Therefore, consumers *as a group* are better off than they were under the free market: They have $4,000 more of consumer surplus per month. However, this outcome hides a big discrepancy. Those students lucky enough to get in on the 6,000 pizzas for $8 rather than $10 are better off, but there are 4,000 pizzas that would have been available in the free market that are no longer being supplied. Students who would have consumed those missing pizzas are worse off than they were before.

What is the deadweight loss from the inefficiency of this price-controlled market outcome? The full DWL is the area of triangle
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in the figure, so

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The Problem of Deadweight Loss

As we have seen, a price ceiling creates a deadweight loss. This deadweight loss is just that: lost. It's surplus that was formerly earned by consumers (*C*) or producers (*E*) that neither gets when there is a price ceiling. This analysis has shown that price ceilings and other mandates and regulations can come with a cost, even if they don't involve any direct payments from consumers or producers the way taxes do.

A natural way to think about the size of the deadweight loss is as a share of the transfer. Because the price control was designed to transfer surplus from pizzerias to students, the deadweight loss tells us how much money gets burned up in the process of transferring surplus through this regulation. In this case, the deadweight loss ($12,000) is just as large as the transfer. In other words, in the process of transferring income from pizzerias to students through the price ceiling, one dollar of surplus is destroyed for every dollar transferred.

This example illustrates the dilemma of using regulations to transfer income. If somehow the city council could get the producers to directly pay the consumers the amount
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without changing the price, the consumers would be just as happy as with the price control, because that's all they net in the deal after losing the deadweight loss. The producers would be better off as well. Rather than being left with just *F*, they would have their free-market producer surplus of
Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and an
minus their payment of

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The areas *D* in these two values cancel, leaving the pizzerias
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which is larger than the *F* in producer surplus they get under the price ceiling law. Deadweight loss occurs because the price-control regulation transfers income by changing prices, and price changes affect incentives and lead to inefficiency. Practically speaking, though, it's difficult to figure out how to organize the payment of
Error parsing MathML: error on line 1 at column 685: Opening and ending tag mismatch: img line 0 and an
without changing the price. A per pizza subsidy paid by pizzerias to students, for example, would have the same result as reducing the price and would thus have its own deadweight loss, as we describe in Section 3.5.

Importance of Price Elasticities

The elasticities of supply and demand are the keys to the relative sizes of the deadweight loss and the transfer. Consider two different pizza markets in Figure 3.7. In panel a, the curves are relatively inelastic and show little price sensitivity. In panel b, the relatively elastic supply and demand curves reflect a greater amount of price sensitivity. It's clear from the figure that if the same price-control rule is applied to both markets, the deadweight loss will be larger as a share of the transfer in the market with more elastic supply and demand.

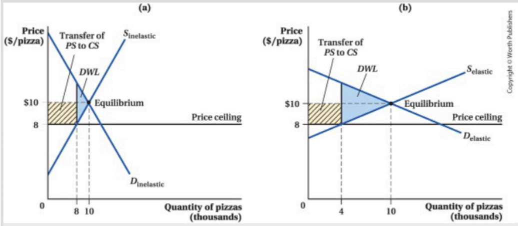

Figure 3.7 Deadweight Loss and Elasticities

(a) Error parsing MathML: error on line 1 at column 832: Opening and ending tag mismatch: img line 0 and annotation-xml and Error parsing MathML: error on line 1 at column 832: Opening and ending tag mismatch: img line 0 and annotation-xml show little price sensitivity. With price controls, relatively few buyers and sellers who would have traded in the free market are kept out of the market, and the transfer is much larger than the deadweight loss created.

(b) In a market with more elastic supply and demand curves, Error parsing MathML: error on line 1 at column 826: Opening and ending tag mismatch: img line 0 and annotation-xml and Error parsing MathML: error on line 1 at column 826: Opening and ending tag mismatch: img line 0 and annotation-xml, a relatively large group of buyers and sellers who would have traded in the free market are kept out of the market, and the deadweight loss created by the price control is much larger than the transfer.

The intuition behind this result is that the price ceiling's deadweight loss comes about because it keeps a set of sellers and buyers who would be willing to trade in the market at the free-market price from doing so. If the number of people in this set is small (in other words, the quantity after the regulation is close to the quantity before), then the deadweight distortion is small. That magnitude depends on how sensitive supply and demand are to prices. If supply and demand are relatively inelastic, the number of people and firms changing their quantity demanded or supplied will be small, and the DWL will be small relative to the transfer. If supply and demand are relatively elastic, the number of people and firms who change their quantity demanded or supplied will be large.

Price Floors

The other major type of price regulation is a price floor (sometimes called a price support), a price regulation that sets the lowest price that can be paid legally for a good or service.

price floor (or price support)
A price regulation that sets the lowest price that can be paid legally for a good or service.

Lawmakers around the world use price floors to prop up the prices of all sorts of goods and services. Agricultural products are a favorite. In the United States, the federal government began setting price supports for agricultural goods such as milk, corn, wheat, tobacco, and peanuts as early as the 1930s. The goal was to guarantee farmers a minimum price for their crops to protect them from fluctuating prices. Many of these price supports remain today. We will use the tools of consumer and producer surplus to analyze price floors just as we used them for price ceilings.

Let's look at the market for peanuts. The unregulated market for peanuts is shown in Figure 3.8. The equilibrium quantity of peanuts is 20 million tons, and the equilibrium price of peanuts is $500 per ton. The government decides that farmers should be getting more than $500 per ton for their peanuts, so it passes a regulation that peanuts must sell for no less than $1,000 per ton.

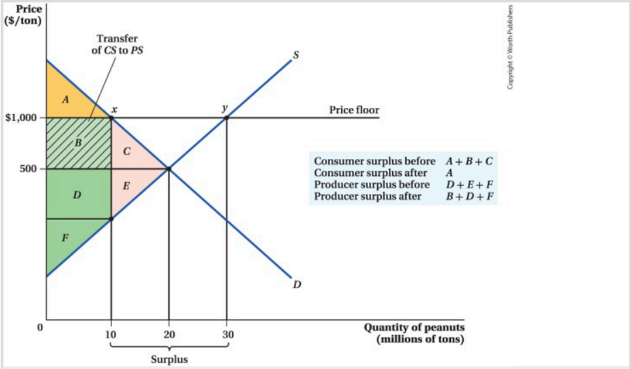

Figure 3.8 The Effects of a Price Floor

A price floor affects both producer and consumer surpluses. Before price controls in the peanut market, consumers pay $500 per ton, and producers supply 20 million tons of peanuts. Consumer surplus is the triangle Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and annotation-xml, and producer surplus is Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and annotation-xml. When a price floor of $1,000 per ton is put in place, peanut farmers supply 30 million tons of peanuts (point *y*), but consumers demand only 10 million tons of peanuts (point *x*), creating an excess supply of 20 million tons of peanuts. Consumer surplus is reduced to *A*. Producer surplus is now Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and annotation-xml, and the net gain to producers is Error parsing MathML: error on line 1 at column 685: Opening and ending tag mismatch: img line 0 and annotation-xml. The deadweight loss is Error parsing MathML: error on line 1 at column 683: Opening and ending tag mismatch: img line 0 and annotation-xml.

Immediately, we know there is going to be a problem. At the higher price, peanut farmers want to sell lots of peanuts—30 million tons. But at that price, quantity demanded is much lower—only 10 million tons. (Peanut butter sandwiches are just too expensive when peanuts cost $1,000 per ton.) This imbalance leads to **excess supply** in the market: the difference between the quantity supplied and the quantity demanded at a price floor. This is indicated in the figure by the 20-million-ton difference between the quantity of peanuts supplied and the quantity demanded at the price floor.

excess supply
The difference between the quantity supplied and the quantity demanded at a price floor.

The goal of the price floor policy is to help farmers, so we need to look at the producer surplus to know how well the policy accomplishes its goal. Before the regulation, producer surplus was the area Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and an After the regulation, prices go up for all the peanut farmers who are still able to find buyers, so producers gain area *B* as a transfer from consumers. The farmers sell 10 million tons of peanuts and receive $500 per ton more than they were receiving in the free market. But peanut growers lose some of their market. The reduction in quantity demanded from 20 million to 10 million tons knocks out producers who used to sell peanuts at market prices and made a small amount of producer surplus from it. This area *E* then becomes the producers' part of the deadweight loss (DWL) from the regulation.

Overall, the producers gain surplus of Error parsing MathML: error on line 1 at column 685: Opening and ending tag mismatch: img line 0 and an If supply and demand are sufficiently elastic (i.e., if both curves are flat enough), producers could actually be made *worse off* from the price floor that was put in place to help them. This is because area *E*—the producers' share of the DWL—may be larger than the transfer from consumers, area *B*. This outcome is another application of our discussion above about how the deadweight loss grows as the supply and demand curves become more elastic.

How do consumers fare when the price floor is enacted? You can probably guess: Consumer surplus falls from Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and an to *A*. Area *B* is the surplus transferred from consumers to producers, and area *C* is the consumers' part of the DWL.

The price floor policy therefore transfers income from consumers to peanut farmers, but only by burning

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(the DWL) to do it. Again, if there were some way for the consumers to directly pay the peanut farmers a set amount equal to area *B*, the farmers would obtain more surplus than they get with the regulation (producer surplus of *B* versus

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and the consumers would be better off too (consumer surplus of

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instead of *A*). By changing the actual price of peanuts instead of making a transfer unrelated to quantity, the price support distorts people's incentives and leads to inefficiency, as reflected by the DWL of

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This analysis also illustrates the everlasting dilemma of price supports. The quantity supplied at the price floor is greater than the quantity demanded. What happens to the extra peanuts? They accumulate in containers rather than being sold on the market. To avoid this outcome, a government will often pay the producers who can't sell their output in the regulated market to *stop* producing the extra output (20 million extra tons of peanuts in our example). The United States Department of Agriculture, for example, oversees various programs to reduce the surplus of price-supported crops on the market. One such program, the Conservation Reserve Program (CRP), paid farmers $1.8 billion in 2017 (an average of about $77 per acre) for holding land out of production. The program does have environmental benefits that mitigate some of the losses, but it also serves to reduce the quantity of subsidized crops that is grown, effectively by replacing those subsidies with CRP payments. There are also a number of programs that distribute hundreds of millions of dollars annually (about $1 billion in 2017) of commodity foods—like peanut butter—to school lunch programs and needy individuals on the condition that the foods not be resold. Again, these programs take surplus crops off the market.

Another example of a price support is a minimum wage. Here, the "product" is labor and the "price" is the wage, but the analysis is the same. If the government tries to help college students save tuition money by mandating that all summer internships pay at least $40 an hour, the quantity of labor supplied for internships will be much greater than the quantity demanded. As a result, there will be a lot of unemployed intern-hopefuls who would have been working at the equilibrium wage.

Just as with our earlier examples, how many people a minimum wage adds to the number of unemployed (the excess quantity supplied in the price floor figure), the amount of income transferred to workers (the change in producer surplus), and the size of the deadweight loss all depend on the elasticity of labor supply and labor demand. The price floor's deadweight loss arises because a set of sellers and buyers who would be willing to trade in the market at the free-market price will not do so at the regulated price. When suppliers and demanders are relatively insensitive to price, the number of transactions that the price floor prevents from happening is relatively small, and therefore so is the deadweight loss. Large price elasticities imply a large number of destroyed transactions and a large deadweight loss relative to the transfer of income. If a price floor is set below the free-market equilibrium price, it is nonbinding, and will have no effect on the market, and will not create excess supply or deadweight loss.

3.3 Quantity Regulations

Sometimes, rather than regulating prices, governments impose quantity regulations. We discuss some of these regulations and analyze their effects on market outcomes in this section.

Quotas

A **quota** is a regulation that sets the quantity of a good or service provided. Quotas are occasionally used to force firms to produce a certain amount of a good (say, a vaccine in preparation for a flu epidemic), but more often they limit the amount of a good.

quota
A regulation that sets the quantity of a good or service provided.

For example, countries wanting to limit imports but not wanting to publicly announce tariffs (taxes on imports) might put a quota on imports. The U.S. government imposes quotas on the amount of sugar that can be imported from various countries, for example.[6] In other circumstances, a government may limit the amount of fish people can catch or the production of milk.[7] France limits the amount of U.S. television shows that can be broadcast on TV. Singapore limits the number of cars that people can buy. London's Heathrow Airport limits the number of direct flights from U.S. airports. Zoning laws impose another type of quota. Most towns have zoning laws that limit what construction can take place in a certain area, such as limiting the number of tattoo parlors.

Let's consider as an example the impact of a quota on the amount of tattoo services that can be provided in the fictional town of River City, where a concerned town council wants to limit tattoos. Suppose the city's demand curve for tattoos is

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and the supply curve is

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is where the quantities demanded and supplied are both measured in the number of tattoos per year. We can analyze the effects of a quota on price and quantity by using graphs or equations.

Graphical Analysis

In the free market, the equilibrium quantity of tattoos supplied and demanded in River City is 1,500 tattoos per year at a price of $50 per tattoo (Figure 3.9).

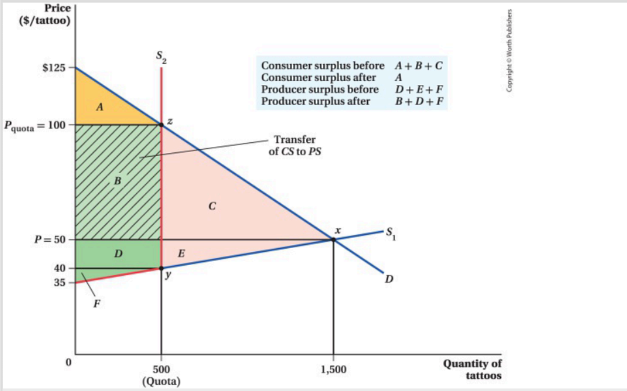

Figure 3.9 The Effects of a Quota

In the free market for tattoos in River City, producers supply 1,500 tattoos per year at a price of $50 per tattoo at the equilibrium (point *x*). Consumer surplus is

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and producer surplus is

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After the mayor of River City enacts a law requiring a permit to get a tattoo, the supply for tattoos becomes vertical at the quantity of 500 tattoos. At the new equilibrium (point *z*), producers supply 500 tattoos at the increased price of $100 per tattoo. Consumer surplus is reduced to *A*. Producer surplus is

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and the net gain to producers is

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The deadweight loss is

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Suppose that River City's mayor believes tattoo shops are a blight on society, decides that people should get no more than 500 tattoos in a year in the city, and enforces this quota by requiring everyone who wants a tattoo to buy a tattoo permit before being inked.

The quota creates a regulatory bend in the supply curve so that it becomes vertical at the quantity of 500. In other words, no matter what the price of tattoos is, parlors cannot supply more than 500. When this happens, the supply curve becomes perfectly inelastic at 500, making the new supply curve
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look like the red line in Figure 3.9. Now the demand curve intersects supply at point *z* rather than at point *x*, and the price rises from $50 to $100. Consumer surplus falls from area
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to area *A*, which is the only area below the demand curve and above the post-quota price
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The post-quota producer surplus is above the supply curve and below the new price. This area
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includes a surplus transfer *B* from consumers to producers. The area
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is the deadweight loss.

Analysis Using Equations

The equilibrium price is the price that exists when quantity supplied equals quantity demanded:

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Solving for *P* and *Q*, we find

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At the free-market equilibrium price and quantity, the consumer surplus is

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The demand choke price
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is the price at which
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which in this case is

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Consumer surplus is therefore

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The producer surplus is the triangle
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in the graph. That triangle's area is

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The supply choke price
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is the price at which quantity supplied is zero:

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Producer surplus in the unregulated tattoo market is then

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After the 500-tattoo quota is implemented, the supply curve is the same up to
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at which point it becomes perfectly inelastic (point *y*). The equilibrium price will be

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At this price, the consumer surplus is the area *A*:

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This is dramatically reduced from the free-market surplus of $56,250. Sorry, River City tattoo fans.

The producer surplus is measured by the areas
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We can break out each of these areas separately:

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The price at point *y* is the price at which the quantity supplied is equal to the quota. It can be determined by setting
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and solving for *P*:

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So, this means

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The rectangle *B* is

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and the rectangle *D* is

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Thus, the total producer surplus equals
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Let's compare the quota outcomes to those of the free, unregulated River City tattoo market. Consumers are much worse off after the quota because their surplus has fallen from $56,250 to only $6,250. This decrease reflects, in part, the losses of the additional 1,000 people who would be willing to get a tattoo in River City in a free market but cannot with the quota in place. However, the loss in consumer surplus also reflects the fact that the quota increases the price of tattoos even for those people who get one. This price increase shrinks the gap between what they are willing to pay for the tattoo and the price they actually have to pay.

On the supply side, the tattoo parlors do just fine. They lose the producer surplus in area *E* when the quota is imposed, but the quantity restriction leads to much higher prices for their output—they get a huge transfer from consumers (area *B*), which makes their total producer surplus $31,250 under the quota instead of $11,250 without it. This gain could explain why the tattoo parlors may not complain about an ordinance that would reduce the total number of tattoos they could sell, although a non-economist might expect they would.

The quantity-restricting quota drives up the price of tattoos. In doing this, the quota transfers a bunch of surplus from tattoo buyers to tattoo parlors and creates a significant amount of deadweight loss (area
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which based on our calculations above totals
Error parsing MathML: error on line 1 at column 994: Opening and ending tag mismatch: img line 0 and an

This analysis took on real-world relevance in 2019 when New York City imposed a quota on the number of ride-share drivers within city limits at companies like Uber and

Lyft. Nominally, they applied the quota to reduce the amount of traffic and improve the quality of life for residents. The basic model suggests, though, that the main impact would be on the prices consumers will have to pay for rides. In fact, taxi companies lobbied hard for the rule, and it's easy to see why.

3.4 Taxes

Governments at all levels (local, state, federal) tax all kinds of things, and they do it in different ways. Sometimes, suppliers pay the tax. Stores in the United States collect sales taxes and send them to state revenue agencies, for example, just as producers in Canada and Europe collect and remit value-added tax (VAT). Sometimes the legal burden for collecting the tax falls on consumers, like "use taxes" that states levy on purchases their residents make in other states. In still other cases, the legal burden is shared. For instance, half of the U.S. federal payroll tax (which funds the Social Security and Medicare programs) is paid by employers before workers get their wages, and the other half is paid by workers through a deduction from their wages.

In this section, we use the supply and demand model to show a striking finding of economics: In a competitive market, it doesn't matter whether the buyer or the seller is required by law to actually pay the tax; the impact on consumers and producers is the same either way. The government could change the law to make consumers pay the sales tax instead of sellers, or to make employers pay the entire payroll tax. In a competitive market, nothing would change. The total impact of a tax on consumers and sellers depends only on the steepness of the supply and demand curves, not who has to pay. Before we can understand why this is true, however, we first need to look at how taxes affect a market.

Tax Effects on Markets

Let's consider the market for cars-for-hire at Chicago's O'Hare and Midway Airports. The city of Chicago, like many municipalities, charges cars-for-hire (taxis, livery, and rideshare companies) a tax each time they pick up passengers at the city's airports. The companies submit the tax, $4 per car, to be allowed to enter the for-hire arrivals pickup lane. Let's look at how this tax affects the market for rides out of the airports using both graphs and equations.

Graphical Analysis

With no taxes, solving the model our usual way gives a free-market equilibrium price
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and quantity
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and the resulting consumer and producer surpluses (Figure 3.10).

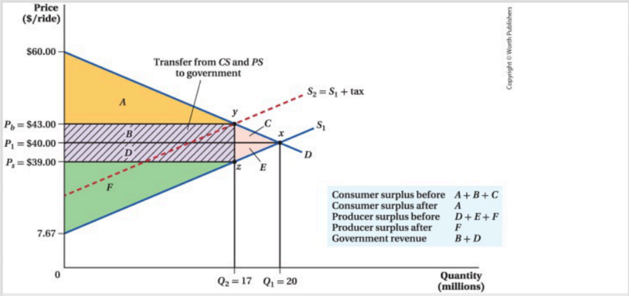

Figure 3.10 Effect of a Tax on Hired Rides from Chicago Airports

In the no-tax market, supply
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and demand *D* intersect at the equilibrium price of $40 and the equilibrium quantity of 20 million car rides. The consumer surplus is
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and the producer surplus is
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The addition of the $4 tax per car results in an upward shift of the supply curve from
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the amount of the tax and decreases the equilibrium quantity to 17 million rides. The resulting tax wedge creates two prices: $43, the price the buyer faces, and $39, the price the seller actually receives. The new consumer surplus is *A*, and the producer surplus is *F*. Area
Error parsing MathML: error on line 1 at column 683: Opening and ending tag mismatch: img line 0 and annotation-xml is
government tax revenue, while area
Error parsing MathML: error on line 1 at column 683: Opening and ending tag mismatch: img line 0 and annotation-xml is
the deadweight loss.

The tax is much like a $4-per-ride increase in for-hire operators' costs. We know from Chapter 2 that increases in production costs cause suppliers to supply a smaller quantity at any given price. Therefore, in response to the tax, the supply curve shifts up by the amount of the tax ($4) to
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
and the equilibrium quantity of rides sold falls to
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[8]

But, taxes do something different from a typical supply shift: They drive a wedge between the price buyers pay (the market price) and the price that producers actually receive (the market price minus the tax). With a normal supply curve, the price at any point on the supply curve is the price a producer receives for selling its product. With a tax, the product sells for the price
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
(we denote the price the buyers pay with a "*b*"), but the sellers only receive
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(we denote the price the seller receives with an "*s*"). This is the buyers' price minus the tax:
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In other words, the buyers have to pay $4 more for any quantity, but the cars-for-hire companies don't get to keep the extra money—they receive only the higher price minus the tax.

Because of this wedge, the new equilibrium in the Chicago airport market involves *two* prices. The first, point *y*, is the price ($43) the buyers pay at the airport that includes the $4 tax. Thus, $43 is the market price. The second, point *z*, is the price ($39) that the suppliers receive after taking the $4 out of the higher market price and sending it to the government.

There are two key things to note about the post-tax market equilibrium. First, the price of car rides increases, but not by the full $4 of the tax. You can see this in Figure 3.10. The size of the tax is reflected in the vertical distance between
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and

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The rise in the price of rides, however, is the distance between $43 and the equilibrium price with no tax, $40. The reason for this discrepancy is that the tax wedge drives some of the highest marginal-cost cars-for-hire out of the market: Once the tax is added to the price, these companies would have to sell their rides at a price that is too high for buyers. The second characteristic to note is that the government generates revenue from the tax. The total revenue equals the $4 tax times

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the new quantity of tickets sold.

We can apply all the familiar concepts from consumer and producer surplus analysis to this new equilibrium. We just need to remember that the tax creates a second supply curve that we have to keep track of, rather than moving a single supply curve as before. The supply curve that the car-for-hire owner cares about is

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the initial supply curve. The number of rides that the companies are willing to supply at any particular price is still given by this curve, even when the tax is imposed, because the level of

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reflects the after-tax dollars cars-for-hire companies take home from selling rides. But the supply curve that the buyers actually face is

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It has been shifted up by the amount of the tax, because that is the price riders have to pay for a particular quantity supplied.

To make things clearer, let's work through this example in more detail. In Figure 3.10, the demand curve for cars for hire in Chicago is

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and the supply of cars for hire is

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where both quantities demanded and supplied in these curves are measured in millions. All cars-for-hire owners are required to remit to the city $4 per ride sold. We can analyze the tax's effect on the market using graphs or equations.

The tax means buyers now face a new supply curve

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equal to

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shifted up by $4, the amount of the tax. This reduces the number of rides bought in the market from 20 million to 17 million. At that quantity, the price the buyers are paying rises from $40 to $43. Because the law requires suppliers (the cars-for-hire companies) to pay the government a $4 tax for every ride they sell, the suppliers don't get to keep $43; they get to keep only

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What happens to consumer and producer surplus changes with the tax? Consumer surplus is smaller. In the no-tax market, consumer surplus would be

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With the tax, it is only *A*, the area below the demand curve but above the price that the buyers have to pay, $43.

The with-tax producer surplus is also smaller. Without the tax, it was

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With the tax, it is only *F*, the area above the supply curve and below the price that the suppliers receive after they pay the tax, $39.

Imposing the tax reduces total producer and consumer surplus from area

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to just area

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Where has the surplus in areas *B*, *C*, *D*, and *E* gone? The area

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is no longer consumer *or* producer surplus; it is government tax revenue, the tax times the quantity sold when the tax is implemented. With a tax, there is no surplus transfer between producers and consumers, as we saw in earlier examples. Instead, both producers and consumers transfer some of their surpluses to the government. This tax revenue is then "returned" to consumers and producers in the form of government services, so it is not lost.

Areas *C* and *E* are the deadweight loss from the tax. They are surpluses that riders and cars-for-hire companies formerly got from buying and selling rides at the competitive price. This surplus is gone now because consumers buy fewer rides at the higher post-tax price and sellers supply fewer rides at their lower post-tax price.

Just as in the price regulation cases, a natural way to look at the size of the deadweight loss is as a fraction of the surplus transfer. Beforehand, that transfer occurred from producers to consumers (for a price ceiling) or from consumers to producers (for a price floor). Now, it's from both to the government. The ratio in this case is the area
Error parsing MathML: error on line 1 at column 683: Opening and ending tag mismatch: img line 0 and an
to the area
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which is the DWL as a share of revenue.

Analysis Using Equations

The demand curve for cars-for-hire in Chicago's airports is
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and the supply of cars is
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where both quantities demanded and supplied in these curves are measured in millions of rides. The no-tax market equilibrium equates quantity demanded and quantity supplied:

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Therefore, without the tax, the equilibrium price would be $40 and 20 million rides would be sold.

The no-tax consumer surplus is the triangle above the price and below the demand curve, as shown in Figure 3.10:

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Again, the choke price is found by determining the price that pushes the quantity demanded to zero:

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In other words, this demand curve says that if rides cost $60, no one will hire a driver to take them out of a Chicago airport. (They'll have to get out somehow, of course. Maybe they would take the "L" train, rent a car that they drive themselves, or have a friend pick them up.)

Plugging the demand choke price into the *CS* formula gives a consumer surplus of
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The producer surplus is the triangle above the supply curve and below the price:

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The supply choke price is the price that moves quantity supplied to zero:

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That is, at any price below $33.33 a ride, no cars-for-hire would offer pickups at Chicago airports. Plugging this supply choke price into the *PS* formula gives a producer surplus of

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What happens to consumer and producer surplus under the $4 tax? Cars-for-hire companies must pay the city for each ride they sell. This creates a dual-supply-curve situation. The supply curve for the cars-for-hire companies is the same as the initial supply curve. The cars-for-hire company is still willing to supply whatever number of rides the supply curve says at the market price. But now, the supply curve buyers face is shifted up by the amount of the tax: At each quantity, the rides supplied to consumers now cost $4 more. The difference between the supply curve that the buyers face and the supply curve that the sellers face is the amount of the tax. In words, the cars-for-hire companies' supply curve says they would be willing to sell 17 million rides if they receive $39 per ride (after the tax gets paid), but for the companies to get $39 per ride, buyers would actually have to pay $43 per ride because the $4 tax needs to be paid out of the price received by the cars-for-hire companies. The prices that result for both the buyer and the seller are summed up in the equation

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To solve for the with-tax quantity and prices, we substitute this expression, which links the two supply prices in our supply and demand equations:

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Therefore, the buyers face the following price:

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Now if we plug the buyers' price into the demand curve equation and the sellers' price into the supply curve equation, they will both give the same with-tax market quantity:

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Only 17 million rides are sold with the tax in place.

The consumer surplus with a tax is the area below the demand curve but above the price that the buyers pay:

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The producer surplus is the area above the supply curve and below the price that the suppliers receive:

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So, the tax makes consumer surplus fall by $55,500,000 and producer surplus fall by about $18,500,000 from their values in the no-tax market equilibrium. Some of that $74,000,000 in lost surplus flows to the government in the form of revenue from the tax, however. That revenue is equal to $4 per ride times the number of rides sold with the tax, or

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Notice that the total amount of the lost surplus is more than the amount of revenue that the government generated. The difference of $6,000,000 is the deadweight loss of the tax.

A different way to calculate DWL is to compute the area of the triangle whose base is the change in quantity and whose height is the amount of the tax:

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That's about 9% of the revenue generated by the tax. In other words, this tax burns up about $1 of surplus in DWL for every $11 of revenue it generates.

Why Taxes Create a Deadweight Loss

Just as we showed in the case of price and quantity regulations, the main determinant of the DWL from a tax as a share of the revenue it generates is how much the quantity changes when the tax is added. The size of that change depends, in turn, on how sensitive supply and demand are to prices. The deadweight loss from pizza price controls, for example, came from consumers and suppliers who would like to trade at market prices and who would have earned surplus from doing so, but were prevented from engaging in these transactions by the price ceiling. With taxes, there are no forbidden transactions. The source of the deadweight loss is the same, however: People who would have hired rides at the market price without a tax and would have gained some surplus from doing so, but who don't buy when the tax raises the price too high. They get to keep their money, but they were previously able to buy something with it that gave them surplus. Likewise, owners of cars-for-hire companies lose surplus because some would have offered rides at the no-tax market price but find the with-tax price too low to justify operating. These lost surpluses are the DWL of the tax.

FREAKONOMICS

Unintended Consequences of a Tax on Garbage

South Norfolk is an idyllic area nestled in the eastern part of England. Yet amid the charming villages, cattle grazing in the fields, the occasional castle on a hill, it is not uncommon to see huge piles of garbage (the British call it "rubbish") strewn haphazardly along the side of the road.

Why are bags of household trash often found along the roadside in Norfolk? The answer is that the local government has used simple economic tools to solve a problem. And those tools have worked. Too well.

Collecting trash is the government's responsibility, and there is a cost associated with collecting trash and putting it in landfills. Governments usually pay for this cost by charging their citizens lump-sum fees; one payment buys any amount of trash removal someone needs, large or small. Because trash is not taxed on the margin, people don't pay the full cost of the garbage they produce, and so they produce more of it. The obvious economic solution is to charge people by the amount of trash they generate. And this is exactly what the South Norfolk District Council aimed to do when it initiated a new garbage pricing policy some years back. The local government placed microchips in garbage bins, with plans to tax citizens by the weight of trash in the bins as measured by the microchips.

roger ashford/Alamy Stock Photo

Fly-tipped garbage on a South Norfolk road.

Some South Norfolk citizens soon realized that they could get around the potential tax by throwing bags of trash out their car window while driving. This kind of illegal dumping, known as *fly-tipping*, accelerated when the policy was put in place and now occurs thousands of times a year. Local governments in the United States, such as Charlottesville, Virginia, have experimented with a per-bag tax on trash. In those jurisdictions, the number of bags of garbage produced plummeted by 37%, consistent with economic theory. But the pounds of trash collected only fell 14%—people had simply stuffed more trash into each bag they threw out. This is not such a bad result … it reduces government revenue, but doesn't cause any other problems.

Evasion of a trash tax doesn't always proceed so smoothly, however. Ireland recently introduced a pay-as-you-throw-away tax, and some people decided to try and avoid the tax by burning their trash. We know this because after the trash tax was imposed, the number of emergency room visits for burns sustained while lighting backyard fires more than doubled![*]

The broader lesson: People react strongly to strong incentives. They change their behavior not only in the way you want them to but also in all sorts of other ways that you might prefer they don't. One of the characteristics that distinguishes good economic analysis from not-so-good analysis is thinking through all the different ways in which behavior might be affected when an incentive changes. So when you call for the next great rule, remember the piles of garbage alongside the roads of South Norfolk and imagine what kind of surprising, devious actions might be the response to your grand plans.

Why a Big Tax Is Much Worse Than a Small Tax

An interesting result of this analysis is that it implies the inefficiency represented by the size of the deadweight loss gets much bigger as the size of a tax becomes larger. In the car-for-hire ride tax example (Figure 3.10), we saw that the DWL from the tax was area

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and that the revenue generated was

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What would happen if Chicago decided to *increase* the ticket tax? How much more revenue and how much more DWL would this tax increase create?

Figure 3.11 illustrates the outcome for a general case. The larger tax reduces the quantity even further, from

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to

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In fact, if taxes become high enough, the increase in revenue per ticket from the tax will be more than offset by the reduction in the quantity of tickets sold, and there will be no revenue gain at all!

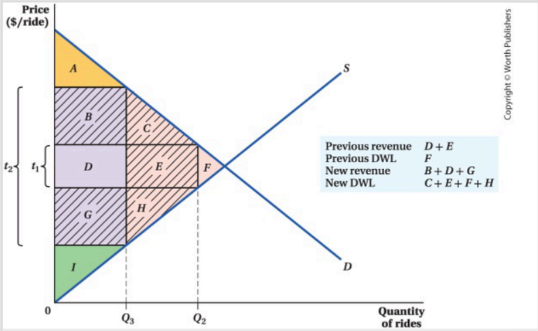

Figure 3.11 The Effect of a Larger Tax on Hired Car Rides at Chicago Airports

After an increase in the tax on hired car rides at Chicago airports from
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to
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the tax wedge between the price consumers pay and the price cars for hire receive increases, while the quantity of rides at the equilibrium
Error parsing MathML: error on line 1 at column 949: Opening and ending tag mismatch: img line 0 and annotation-xml
decreases. Government revenue, which was area
Error parsing MathML: error on line 1 at column 683: Opening and ending tag mismatch: img line 0 and annotation-xml
with a smaller tax, is now area
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However, the government loses area *E,* because some people stop hiring car rides after the tax is raised. If we look at the DWL as a share of the revenue generated, it is clear that the *incremental* revenue generated by increasing this tax causes more inefficiency than the smaller tax did. Initially, the DWL was *F*, with a revenue gain of
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But the incremental DWL here is
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while the revenue gain is only

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A general rule is that the DWL of a tax rises with the square of the tax rate.[9] That is, doubling the tax rate quadruples the DWL. All else equal, taxing 10 things at a low rate is better than taxing 5 things at zero and 5 things at a high rate. Because DWL rises with the square of the tax rate, the overall DWL will be larger with the 5 high rates than with the 10 low rates.

The Incidence of Taxation: The Payer Doesn’t Matter

An important thing to note about the rides from the airport example is that although we supposed that it would be the cars-for-hire companies who were legally obligated to pay the $4 per ride tax to the City of Chicago, they don’t bear the complete burden of the tax. If no tax existed, the car owners received $40 per ride and riders paid $40 a ride. After the $4 tax, riders pay $43 a ticket. After the cars-for-hire companies submit their tax payment, however, they only end up with $39 per ride. Therefore, of the $4 per ride going to the government, $3 (75%) of it is coming out of consumers’ pockets because their price went up by $3. Cars-for-hire companies send the taxes they owe to the government, but they are able to pass on much of that tax to consumers through higher prices. This means that the price realized by the suppliers goes down by only $1. Who *really* bears the burden of a tax is called **tax incidence**. The incidence of this tax is 75% on the buyers and 25% on the suppliers.

tax incidence
Who *really* bears the burden of a tax.

Now let’s say Chicago changed the rule for who pays the tax to the government. Instead of the cars-for-hire owner sending the tax payment to the government, riders would pay the tax by having to cough up $4 before they could stand in line at the pickup lane. This changes who physically pays the tax, but it does not alter the tax incidence. The equations below show why. In the tax formula, it doesn’t matter whether you subtract the tax from what the supplier receives or add the tax to what the buyer pays. Error parsing MathML: error on line 1 at column 1089: Opening and ending tag mismatch: img line 0 and a is the same as

Error parsing MathML: error on line 1 at column 1087: Opening and ending tag mismatch: img line 0 and a Having riders pay $4 to wait for a ride shifts their demand curves down by that amount. Given such a shift, the supplier has to charge less for the rides to find the price that equates quantity demanded and supplied (now $39). Just as in the case where the cars-for-hire companies paid the tax, riders end up paying a total of $43 to take a ride. They've paid $4 to get into line, but effectively $1 of that tax was paid by drivers because of the lower market-clearing (pre-tax) price for rides.

You can also see this same scenario at play in a graph. The original case where the cars-for-hire company pays the tax is shown in **Figure 3.12a**. When the buyers instead pay the tax, their quantity demanded depends on the full price, including the tax. But the price suppliers receive at this quantity demanded is only the price without the tax. To account for this difference, we shift down the demand curve by the amount of the tax, from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an in Figure 3.12b. But the result hasn't changed: Quantity demanded is still Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an and the difference between the buyers' price and the sellers' price still equals the amount of the tax. Thus, the incidence of a tax does not depend on who is legally bound to pay it.

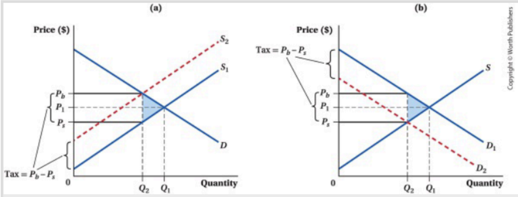

Figure 3.12 Tax Incidence

(a) The tax incidence is unaffected by whether the seller or buyer pays the tax. When the seller pays the tax, the supply curve shifts upward by the amount of the tax, Error parsing MathML: error on line 1 at column 933: Opening and ending tag mismatch: img line 0 and annotation-xml, from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml. The equilibrium quantity decreases from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml. The seller now faces price Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml at the equilibrium, while the buyer pays price Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml.

(b) When the buyer pays the tax, the demand curve shifts downward by the amount of the tax, Error parsing MathML: error on line 1 at column 933: Opening and ending tag mismatch: img line 0 and annotation-xml, from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml. The equilibrium quantity decreases from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml. As in panel a, the seller now faces price Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml at the equilibrium, while the buyer pays price Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml.

That's why a helpful way to picture taxes on a graph is to just forget about whether the tax is moving the supply curve up or the demand curve down. Instead, start from the initial no-tax equilibrium point and move left until the vertical space between the supply and demand curves is the amount of the tax. This gives you the right answer regardless of whether the tax is being legally applied to suppliers or buyers.

A+ make the grade

Did I measure deadweight loss correctly?

A few simple tricks will help you nail problems involving deadweight loss. First, whenever the quantity consumed falls as a result of a government policy, a deadweight loss occurs. (This isn't *exactly* correct; if externalities are present, government policies can actually improve market outcomes. We will learn more about externalities in Chapter 17.) If the quantity doesn't become distorted, no deadweight loss occurs. Second, the deadweight loss almost always takes the shape of a triangle, and moreover, that triangle points at the efficient market equilibrium with no market distortion. Why? Because deadweight loss measures the consumer and producer surplus destroyed. As we have seen, this loss in surplus grows as we move further and further away from the efficient equilibrium. The growing distance between the sides of the triangle reflects this fact.

This point about tax incidence is fundamental. In almost all countries of the world, the government imposes payroll taxes on workers' wages. In the United States, it collects them to pay for Social Security and Medicare, but the tax, which totals 15.3%, is split evenly between workers and employers. In other words, if you earn wages of $1,000, you have to pay $76.50 (7.65%) of that in payroll taxes and the employer has to pay another $76.50 (the remaining 7.65%).[10] Some people propose switching things so that employers would pay the 15.3% and workers would pay nothing. Others say only workers, not employers, should pay taxes. The analyses we've just completed suggest that such changes wouldn't make any difference. In a competitive market, the wage would adjust to the same level regardless of which side of the market is legally bound to pay the tax.

It turns out the only thing that matters about the economic effects of this tax is how elastic the supply and the demand for labor are. To see why, consider the two extremes.

Relatively Elastic Demand with Relatively Inelastic Supply

In a market characterized by relatively elastic demand and inelastic supply, buyers are very sensitive to price and the suppliers are not. Most labor economists tend to think of the labor market in this way: Labor supply is fairly inelastic (people work the same amount at different wage levels) and firms' demand for labor is fairly elastic. This market is illustrated in **Figure 3.13a**.

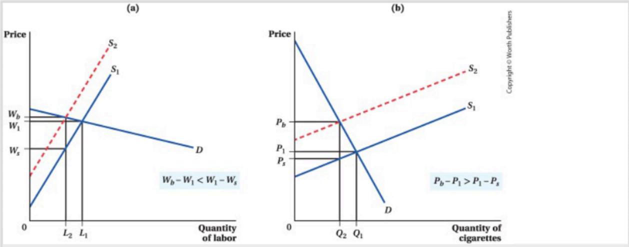

Figure 3.13 Tax Incidence and Elasticities

(a) In a labor market where demand is elastic and supply inelastic, we begin with supply curve Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml, demand *D*, and equilibrium price and quantity Error parsing MathML: error on line 1 at column 1286: Opening and ending tag mismatch: img line 0 and annotation-xml. The implementation of the tax, Error parsing MathML: error on line 1 at column 933: Opening and ending tag mismatch: img line 0 and annotation-xml, shifts the supply curve upward from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml and decreases the equilibrium quantity of labor from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml. Because laborers in this market are not very sensitive to price and employers are, the effect of the tax on the wages laborers receive is much larger than its effect on the wage employers pay, Error parsing MathML: error on line 1 at column 1421: Opening and ending tag mismatch: img line 0 and annotation-xml.

(b) In the market for cigarettes where demand is inelastic and supply elastic, we begin with supply curve Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml, demand *D*, and equilibrium price and quantity Error parsing MathML: error on line 1 at column 1286: Opening and ending tag mismatch: img line 0 and annotation-xml. The implementation of the tax, Error parsing MathML: error on line 1 at column 933: Opening and ending tag mismatch: img line 0 and annotation-xml, shifts the supply curve upward from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml and decreases the equilibrium quantity of cigarettes from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml. Because smokers in this market are not very sensitive to price and cigarette companies are, the effect of the tax on the price consumers pay is much larger than its effect on the price companies receive, Error parsing MathML: error on line 1 at column 1423: Opening and ending tag mismatch: img line 0 and annotation-xml.

Applying the methods we've used throughout this section, we see that a payroll tax would be borne almost entirely by the workers—they are the supply curve of labor. With a tax, employers have to pay wages
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
that are a bit higher than wages without the tax,
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
But after taxes, the workers receive a wage
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
that is much less than
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
Therefore, workers are a lot worse off after the tax than employers. And we know from the discussion we just had on tax incidence that even if the government switched the payroll tax rules so that employers paid the entire amount, workers would not do any better. Their wages would fall almost as much as the employers' tax went up.

Relatively Inelastic Demand with Relatively Elastic Supply

Figure 3.13b shows a market characterized by relatively inelastic demand (buyers are not sensitive to price) and elastic supply (suppliers are very sensitive to price). In the market for cigarettes, for instance, many buyers are addicted to nicotine and buy a similar amount no matter how much the price goes up. Cigarette supply is more elastic. As you can see in the figure, consumers bear the burden of the tax in this case. A tax on cigarettes causes the buyers' price to rise from
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
to
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
almost the entire amount of the tax. Suppliers are only a bit worse off than they were before, because they can pass on the higher costs to the inelastic consumers.

We could do this entire analysis using equations, as we did in the cars-for-hire example. It turns out there is a general formula that will approximate the share of the tax borne by the consumer and the share borne by the producer. Not surprisingly, given what we've just discussed, these shares depend on elasticities:

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figure it out 3.3

Consider the demand and supply for cola in a market represented by the following equations:

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where *Q* is millions of bottles per year and *P* measures dollars per bottle. The equilibrium price of cola is $1.30 per bottle, and 2 million bottles are sold each year.

a. Calculate the price elasticity of demand and the price elasticity of supply at the equilibrium price and quantity.
b. Calculate the share of a tax that would be borne by consumers and the share borne by producers.
c. If a tax of $0.15 per bottle is imposed, what would be the expected price buyers will have to pay? What price will sellers receive after the tax?

Solution:

a. The formula for price elasticity of demand is
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From the demand curve, we can calculate
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Each time *P* changes by 1 unit,
Error parsing MathML: error on line 1 at column 707: Opening and ending tag mismatch: img line 0 and annotation-xml
falls by 10. Therefore,

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Substituting into the formula for elasticity, we get

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The formula for price elasticity of supply is

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From the supply curve, we can see that
Error parsing MathML: error on line 1 at column 1421: Opening and ending tag mismatch: img line 0 and annotation-xml.
Note that each time *P* increases by 1 unit,
Error parsing MathML: error on line 1 at column 707: Opening and ending tag mismatch: img line 0 and annotation-xml
rises by 40.

Thus, the price elasticity of supply is

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b. The proportion of the tax borne by buyers will be

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The proportion of the tax borne by sellers will be

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So, buyers will bear 80% of the tax and sellers will bear only 20% of the tax.

c. If there is a tax of $0.15 per bottle, buyers will bear 80% of the tax:

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The price buyers pay will rise from $1.30 per bottle (the original equilibrium price) to $1.42.

Sellers will bear the other 20% of the tax:

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The price sellers receive will fall from $1.30 per bottle to $1.27.

If the price elasticity of supply

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is infinite, the consumers' share is equal to 1; that is, consumers bear the whole burden when supply is perfectly elastic. If the absolute value of the price elasticity of demand

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is infinite, the consumers' share of the tax burden is zero, and suppliers bear the whole burden of the tax.

3.5 Subsidies

A **subsidy** is a payment by the government to a buyer or seller of a good or service. It is, in essence, the exact opposite of a tax. In fact, when we analyze the effects of subsidies on markets, we can treat the subsidy as a negative tax. Thus, the price the buyer pays is *lower* than the price the supplier receives after the subsidy. If the government subsidizes gasoline by $1 per gallon, for example, then buyers might pay $3.50 per gallon at the pump, but gas stations receive $4.50 per gallon because they get to add the government dollar to the $3.50. This relationship is

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the price the seller receives after the subsidy is paid.

subsidy
A payment by the government to a buyer or seller of a good or service.

Let's look at the effects of the U.S. government subsidy for the domestic production of ethanol, a corn-based fuel additive that can be mixed with gasoline (**Figure 3.14**). (A common rationale given for the subsidy is to reduce the dependence of the United States on imported oil, though not coincidentally, politicians from large corn-producing states have been the most vocal backers of the policy.) This ethanol subsidy would effectively be a subsidy on gasoline that is mixed with ethanol.

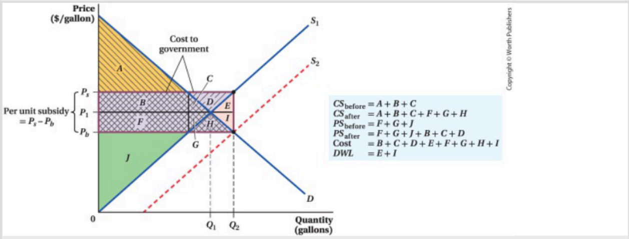

Figure 3.14 The Impact of a Producer Subsidy

In the pre-subsidy market for gasoline, the supply curve

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intersects the demand curve *D* at the equilibrium price
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and equilibrium quantity
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The consumer surplus is
Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and annotation-xml,
and the producer surplus is
Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and annotation-xml. If the government gives fuel producers $1 for every gallon of gas–ethanol mix they sell, the supply curve shifts down by the amount of the subsidy,
Error parsing MathML: error on line 1 at column 944: Opening and ending tag mismatch: img line 0 and annotation-xml, to
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml.
The supply curve that buyers face is lower because the amount people pay to fill their tank is less than the amount the gas station receives, since the government is footing part of the bill (the effects of a tax are just the opposite). At the equilibrium, the quantity increases to
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the price facing suppliers is
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and the price facing buyers is
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Consumer surplus is now
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and producer surplus is
Error parsing MathML: error on line 1 at column 1131: Opening and ending tag mismatch: img line 0 and annotation-xml.
The cost of the subsidy is
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and the deadweight loss is
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Therefore, the costs associated with the subsidy are larger than the sum of the benefits to producers and consumers.

Before the subsidy was in place, consumer surplus was everything below the demand curve and above the price that consumers pay
Error parsing MathML: error on line 1 at column 949: Opening and ending tag mismatch: img line 0 and an
area
Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and an
in Figure 3.14. After the subsidy, consumer surplus will change. But it will not get smaller, as in the case of a tax. It will get larger. The new consumer surplus is the area below the demand curve and above the price that the consumers have to pay (the new lower price,
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This is the old consumer surplus
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plus the new part
Error parsing MathML: error on line 1 at column 795: Opening and ending tag mismatch: img line 0 and an
This additional surplus comes from the lower price and the additional sales at that price.

Before the subsidy, the producer surplus was everything above the supply curve but below the price the suppliers received
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area
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After the subsidy, producer surplus gets bigger, too. The area above the producers' own supply curve
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and below the price that the suppliers receive
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is now
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plus
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(We calculate producer surplus using the producers' supply curve
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because this is the supply curve that the suppliers actually receive and embodies the suppliers' costs of production.)

Note that parts of the consumer and producer surplus areas overlap in this case (areas
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because both sides are getting more surplus than before. The only way this is possible, however, is if someone else foots the bill. In this case, it's the government. The subsidy costs money. The cost of the subsidy is the subsidy amount times the quantity produced,

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which amounts to the rectangle

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This isn't the only cost of the subsidy, however. Like any other price regulation, a subsidy also creates deadweight loss. It might seem odd at first that there would be DWL when both consumers *and* producers are better off after the subsidy. The key is to compare how much their surplus goes up to how much the subsidy costs the government. While consumer surplus went up by

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and producer surplus by

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total government outlays for the subsidy were

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Therefore, the subsidy's DWL is

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Society as a whole pays more for the subsidy than the added benefit it gives to consumers and producers. If somehow the government could just turn over the subsidy revenue to consumers and producers without changing the price, society would be better off. Changing the price gets some extra people to buy gas–ethanol mix who really were not interested in purchasing it before.

When we looked at the market interventions earlier in this chapter, the DWL derived from the surplus lost by people who would have bought if there were no tax or regulation, but do not buy when the tax is in place and the price is too high. Here, it is the other way around. The DWL comes from people who would *not* have made a purchase in a competitive market. They only make a purchase because the subsidy lowers the price. The amount they value the extra quantity is less than what it costs the government to move them to buy it. Some people say buying presents for gift-giving holidays like Christmas or Diwali is inefficient for the same reason—people give gifts that cost about 15% more than the receivers value them.[11]

figure it out 3.4

Suppose the demand for, and supply of, ethanol in a small town are as follows:

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where *Q* measures gallons per day and *P* represents price per gallon. The current equilibrium price is $4, and the current equilibrium quantity is 5,000 gallons per day.

Now suppose that the government wants to create a subsidy of $0.375 per gallon to encourage the use of ethanol.

a. What will happen to the price buyers pay per gallon, the price sellers receive per gallon, and the number of gallons consumed each day?
b. How much will this subsidy cost the government (and ultimately taxpayers)?

Solution:

a. Determining the prices that buyers and sellers face under a subsidy is done in a way similar to how we determined the prices for buyers and sellers in the presence of a tax. However, there is one big difference. Now, the price sellers receive is actually larger than the price paid by buyers (due to the subsidy):

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Now we know that in our problem,

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Remember that we need to start with the demand and supply equations in the following form:

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Once we have come up with these, we can substitute for
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in the supply equation so that it becomes

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Next, we can equate
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and
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to solve for
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To solve for the quantity of ethanol sold after the subsidy is put in place, we can substitute

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into the demand equation or substitute
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into the supply equation. (It is a good idea to do both to check your work.)

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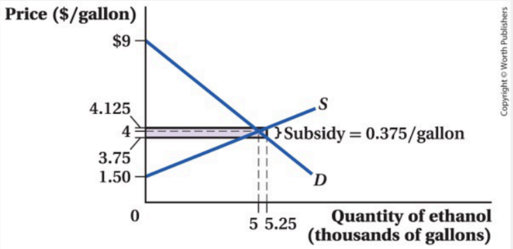
So, buyers will pay $3.75 per gallon, sellers will receive $4.125 per gallon, and 5,250 gallons will be sold each day. This can be seen in the figure below.



b. The cost of the subsidy will be the subsidy per gallon multiplied by the number of gallons sold:

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3.6 Conclusion

In this chapter, we took the supply and demand hammer and pounded every nail in sight. We saw how you can compute the consumer and producer surplus generated by transactions in a market, learned how to value new goods, and learned what deadweight loss is. We learned to use supply, demand, and total surplus to analyze industries and the ways in which they change in response to changes in the market, particularly to price and quantity regulations, taxes, and subsidies. Being able to do so much with such a simple model makes supply and demand the workhorse of microeconomics.

Summary

1. **Consumer surplus** is the value that consumers receive from participating in market transactions. It is the difference between the most they would pay for something and the price they actually have to pay for it. On a supply and demand graph, consumer surplus is measured by the area under the demand curve and above the price. **Producer surplus** is the benefit that producers receive from participating in market transactions. It is the difference between what they sell their product for and the least they would be willing to receive to sell their product. On a supply and demand graph, producer surplus is measured by the area above the supply curve and below the price. [Section 3.1]
2. Using consumer and producer surplus, we can compute how shifts in supply and demand affect the well-being of customers and of companies. An inward shift in supply will cause consumer surplus to fall because of both the increase in the equilibrium price and the decrease in the equilibrium quantity. An outward shift in supply, on the other hand, raises consumer surplus. An inward shift in demand leads to a drop in producer surplus because it decreases both the equilibrium price and quantity. Outward demand shifts have the opposite effect. [Section 3.1]
3. If the government imposes a price regulation—either a maximum price or **price ceiling** like rent control or a minimum price or **price floor** like the minimum wage—the quantities supplied and demanded will differ at the market price, resulting in either **excess demand** or **excess supply** of the good. Such regulations also create a **deadweight loss (DWL)** that arises because some of the surplus-creating transactions that took place before the regulation was enacted do not occur in the regulated environment. A direct transfer of income from one side to the other without changing the price would be a more efficient way to help consumers and suppliers. Deadweight losses are largest when supply and demand are most elastic. [Section 3.2]
4. If the government introduces a regulation that mandates the provision of a given quantity of a good or service (a **quota**) this action will change the market and create a deadweight loss, just as a price regulation does. These actions do not create excess demand or supply, though, because prices are able to adjust and clear the market. [Section 3.3]
5. Taxes reduce output and raise price. In doing so, they reduce consumer and producer surplus but generate tax revenue. The revenue they generate is less than the damage they do to surplus, and the difference is the deadweight loss of the tax. The concept of **tax incidence** tells us who really bears the burden of a tax: It does not matter who actually pays a tax by law. All that matters is the elasticities of supply and demand. The more elastic side of the market will bear less of the burden because it can more easily shift away from the taxed good. [Section 3.4]
6. **Subsidies** increase both consumer and producer surplus relative to the free-market equilibrium. They still create a deadweight loss, though, because the outlay cost of the subsidy exceeds the amount by which it increases the surplus of the two groups. [Section 3.5]

Review Questions

1. Define consumer and producer surplus.
2. How does the demand choke price relate to consumer surplus?
3. How does the supply choke price relate to producer surplus?
4. How does a supply shift affect consumer and producer surplus in a given market? Consider both inward and outward shifts of the supply curve.
5. How does a demand shift affect consumer and producer surplus in a given market? Consider both inward and outward shifts of the demand curve.
6. What is a price ceiling? Why does a price ceiling create excess demand for (shortage of) a good?
7. What is a price floor? Why does a price floor create an excess supply of (surplus of) a good?
8. What is a deadweight loss? If the price elasticity of a good is large, would you expect the deadweight loss to be large or small?
9. When is a price ceiling nonbinding? When is a price floor nonbinding?
10. What is a quota? How does it differ from a price ceiling or a price floor?
11. What happens to the equilibrium price and quantity of a good when a tax is imposed on the good? Why does a tax create a wedge between the price the consumer pays and the price the producer receives?
12. How does a tax affect consumer and producer surplus? Why does a tax create a deadweight loss?
13. What is the tax incidence? What factors determine the tax incidence?
14. What is a subsidy?
15. How does a subsidy affect consumer and producer surplus?
16. Why does a subsidy create a deadweight loss?

Problems

1. Consider the demand for broadband Internet service, given as follows:

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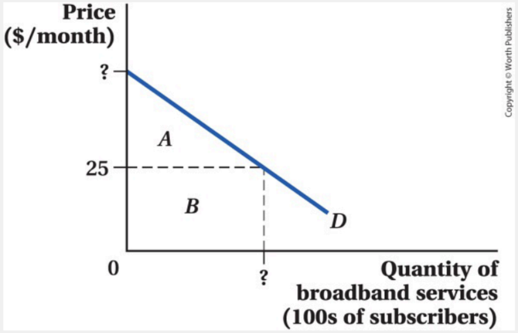
   where *Q* is the number of subscribers in a given area (in hundreds) and *P* is the price in dollars per month. This demand relationship is illustrated in the diagram below. Assume that the price of broadband service is $25 per month. Determine the following, paying particular attention to the units in which quantity is denominated:

   a. The total number of subscribers at that price

   b. The total amount paid by subscribers for broadband service, area *B*

   c. The consumer surplus received by subscribers, area *A*

   d. The total value to consumers of the broadband service they received, areas *A* and *B*



2. Consider the following diagram, which depicts the supply of broadband Internet service. The supply of broadband service is given by

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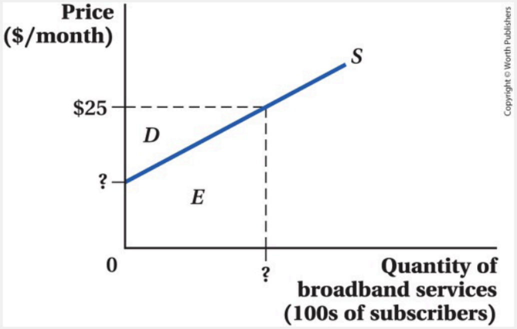
   where *Q* is the quantity of services (in hundreds) and *P* is the price per month. Assume that the price of broadband service is $25 per month. Determine the following, paying particular attention to the units in which quantity is denominated:

   a. The total number of services providers will supply at that price

   b. The total amount received by producers for that service, areas *D* and *E*

   c. The producer surplus received by suppliers, area *D*



3. The annual demand for full-spectrum LED light bulbs in Fairbanks, Alaska, is estimated to be

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   The supply is estimated to be

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a. Find the equilibrium price and quantity of LED light bulbs in Fairbanks, Alaska.

b. Calculate the consumer and producer surplus at the equilibrium price.

c. What is the total surplus created in the market for LED light bulbs?

4. Increases in demand generally result in increases in consumer surplus. But that's not always true. Illustrate a situation in which an increase in demand actually results in a *decrease* in consumer surplus. What conditions on the supply side of the market make this more likely to occur?

5. The Ministry of Tourism in the Republic of Palau estimates that the demand for its scuba diving tours is given by

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where *Q* is the number of divers served each month and *P* is the price of a two-tank dive. The supply of scuba diving tours is given by

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The equilibrium price is $160, and 2,800 divers are served each month. A new air route from Australia increases the number of dives demanded at each price by 1,000 per week.

a. What is the equation for the new demand curve?

b. What are the new equilibrium price and quantity?

c. What happens to consumer and producer surplus as a result of the demand change?

6. In 1997, Sony introduced the DVD player, replacing the VHS videotape and shepherding in a new era of high-definition movie viewing. Soon, there were over 100 different player models competing. DVD became the standard, preferred way to watch movies at home; VHS movies became increasingly difficult to rent and/or purchase. Then, in 2010, Netflix introduced streaming video that allowed users to watch movies on their television or mobile device.

a. Explain why the consumer surplus gained by those purchasing DVD players was likely to be quite high between 1997 and 2010.

b. Describe how the introduction of streaming video likely altered the consumer surplus received by purchasers of DVD players after 2010.

c. Do you believe the consumer surplus received by *movie viewers* increased or decreased after 2010? Explain.

7. Unskilled workers operate in a competitive market. The labor supply is

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(where *W* is the price of labor measured by the hourly wage) and the demand for labor is

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measures the quantity of labor hired (in thousands of hours).

a. What are the equilibrium wage and quantity of low-skilled labor working in equilibrium?

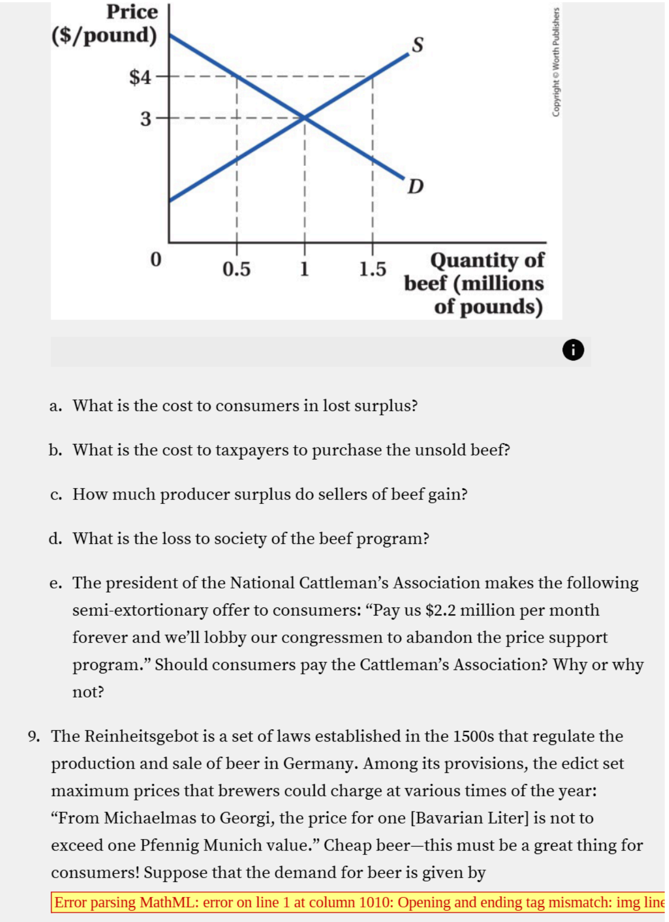
b. If the government passes a minimum wage of $15 per hour, what will the new quantity of labor hired be? Will an excess demand or excess supply of labor exist? How large?

c. What is the deadweight loss of a $15 minimum wage?

d. How much better off does the $15 minimum wage make low-skilled workers (in other words, how much does producer surplus change), and how much worse off are employers?

e. How would your answers to (c) and (d) change if the minimum wage was set at $17, rather than $15?

8. The diagram below illustrates the market for beef. Suppose that the government has instituted a price support program for beef by placing a price floor at $4.00 per pound. Under the program, any unsold beef will be purchased by the government and placed in long-term storage.


Price
($/pound)
$4
3
S
D
0
0.5
1
1.5
Quantity of beef (millions of pounds)
Copyright © Worth Publishers

a. What is the cost to consumers in lost surplus?

b. What is the cost to taxpayers to purchase the unsold beef?

c. How much producer surplus do sellers of beef gain?

d. What is the loss to society of the beef program?

e. The president of the National Cattleman’s Association makes the following semi-extortionary offer to consumers: “Pay us $2.2 million per month forever and we’ll lobby our congressmen to abandon the price support program.” Should consumers pay the Cattleman’s Association? Why or why not?

9. The Reinheitsgebot is a set of laws established in the 1500s that regulate the production and sale of beer in Germany. Among its provisions, the edict set maximum prices that brewers could charge at various times of the year: “From Michaelmas to Georgi, the price for one [Bavarian Liter] is not to exceed one Pfennig Munich value.” Cheap beer—this must be a great thing for consumers! Suppose that the demand for beer is given by

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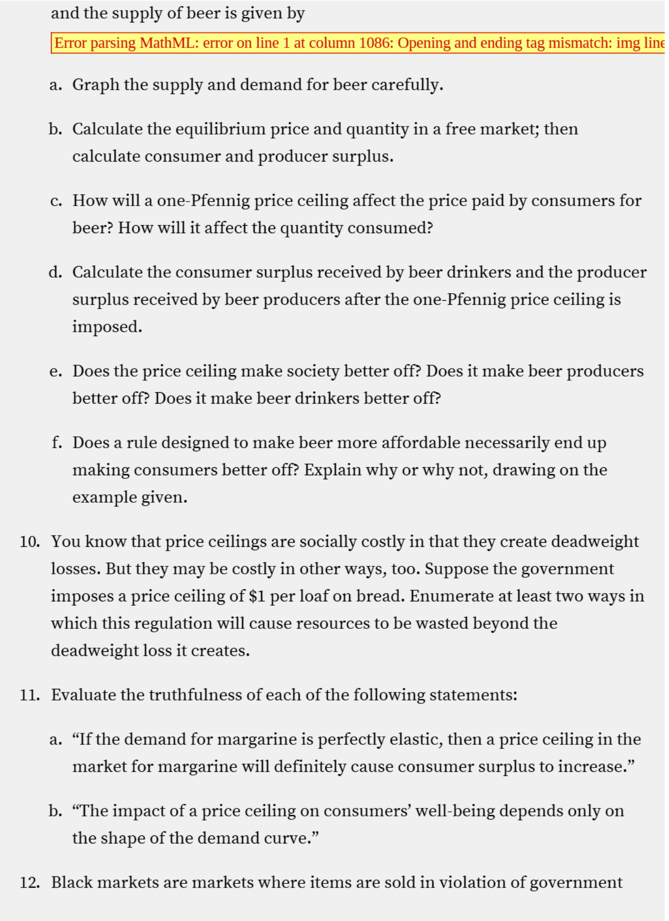

and the supply of beer is given by

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a. Graph the supply and demand for beer carefully.

b. Calculate the equilibrium price and quantity in a free market; then calculate consumer and producer surplus.

c. How will a one-Pfennig price ceiling affect the price paid by consumers for beer? How will it affect the quantity consumed?

d. Calculate the consumer surplus received by beer drinkers and the producer surplus received by beer producers after the one-Pfennig price ceiling is imposed.

e. Does the price ceiling make society better off? Does it make beer producers better off? Does it make beer drinkers better off?

f. Does a rule designed to make beer more affordable necessarily end up making consumers better off? Explain why or why not, drawing on the example given.

10. You know that price ceilings are socially costly in that they create deadweight losses. But they may be costly in other ways, too. Suppose the government imposes a price ceiling of $1 per loaf on bread. Enumerate at least two ways in which this regulation will cause resources to be wasted beyond the deadweight loss it creates.

11. Evaluate the truthfulness of each of the following statements:

a. “If the demand for margarine is perfectly elastic, then a price ceiling in the market for margarine will definitely cause consumer surplus to increase.”

b. “The impact of a price ceiling on consumers’ well-being depends only on the shape of the demand curve.”

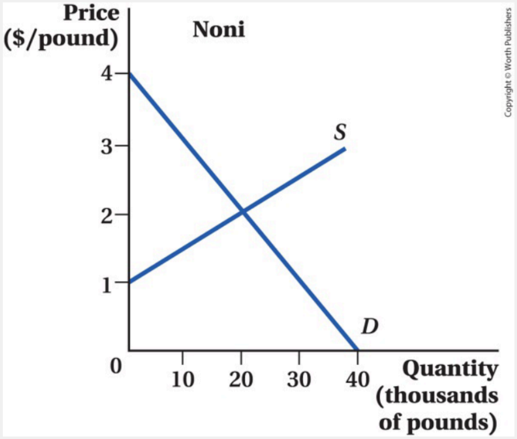
12. Black markets are markets where items are sold in violation of government

rules and regulations.

a. Suppose that the government imposes a $1 per loaf price ceiling on bread sales, well below its free-market price. Explain how the existence of a black market for bread could potentially improve society's well-being.

b. Suppose that the government establishes a $20 per bushel price floor in the market for corn. Explain how the existence of a black market for corn could potentially improve society's well-being.

13. Noni is a tropical fruit grown in Hawaii and widely marketed as an herbal cure for various diseases. The market for Noni fruit is depicted in the graph below.



Concerned that Noni fruit may be habit-forming and produce adverse side effects, the U.S. Department of Agriculture (USDA) and the Food and Drug Administration (FDA) decide to reduce the quantity of Noni available by restricting production to 10,000 pounds monthly.

a. Alter the supply curve to show the impact of the quantity regulation on the market for Noni.

b. What will the market price of Noni be after the regulation goes into effect?

c. What will happen to consumer surplus as a result of the regulation?

d. "We, the producers of Noni fruit, stand united against these intrusive and unnecessary quantity restrictions. Until the dangers of Noni consumption are fully documented, we will fight for the freedom to produce all the Noni we want!" Given this public proclamation, do you expect Noni growers to fight hard against these regulations?

14. You are a USDA economist, and the Senate Finance Committee has come to you for advice. The government is considering bolstering its finances by imposing a tax on either salt or blue cheese. You know that the markets for salt and blue cheese are roughly the same size, although the demand for salt is highly inelastic, whereas the demand for blue cheese is highly elastic. Salt and blue cheese have similar supply elasticities. Which option do you recommend as the least costly choice?

15. The demand for ice cream is given by

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measured in gallons of ice cream. The supply of ice cream is given by

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a. Graph the supply and demand curves, and find the equilibrium price and quantity of ice cream.

b. Suppose that the government legislates a $1 tax on a gallon of ice cream, to be collected from the buyer. Plot the new demand curve on your graph. Does demand increase or decrease as a result of the tax?

c. As a result of the tax, what happens to the price paid by buyers? What happens to the price received by sellers? How many gallons of ice cream are sold?

d. Who bears the greater burden of the tax? Can you explain why this is so?

e. Calculate consumer surplus both before and after the tax.

f. Calculate producer surplus both before and after the tax.

g. How much tax revenue did the government raise?

h. How much deadweight loss does the tax create?

16. Every autumn brings an increase in the demand for pumpkin spice lattes (PSL). This fall, the demand for PSLs in a mid-sized midwestern town is given by

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where *P* is the price of a PSL in dollars and *Q* is thousands of PSLs per day. The corresponding supply is given by

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The equilibrium price of a PSL is $6; the equilibrium quantity is 7,000.

a. Calculate the price elasticity of demand and the price elasticity of supply at the equilibrium price and quantity.

b. Eager to capitalize on the addictive nature of the PSL, the City Council decides to impose a $1 tax on PSLs. “We can use the proceeds to fund an espresso machine for City Hall!” they rave. Using your answer to (a), calculate the share of the tax borne by consumers of PSLs, and the share of the tax borne by sellers.

c. Determine the expected price buyers will have to pay after the tax is imposed. Then calculate the expected price sellers will receive after the tax.

17. The U.S. Senate is considering a bill that would tax the sale of laptop computers in order to fund a computer education program for middle school students. The Congressional Budget Office (CBO) estimates that if it implements a low tax of $12 per laptop, revenue should be sufficient to exactly fund the program. The CBO also estimates that a high tax of $230 per laptop will exactly fund the program.

a. How can both a low tax and high tax raise exactly enough money to fund the program? Illustrate your answer using a graph.

b. Suppose that you are an economic advisor to the Senate Finance Committee, tasked with analyzing the economic impact of the tax proposals. Which proposal do you recommend and why?

18. A tax increases the price paid by buyers and reduces the price received by sellers; it makes society worse off. In contrast, a subsidy reduces the price paid by buyers and increases the price received by sellers. True or false: Because a subsidy’s effects are the opposite of a tax’s effects, the subsidy must make society better off. Explain your reasoning.

19. The government believes that access to the Internet is essential in today’s society, and to bolster access, it proposes subsidizing the purchase of mobile devices. The inverse demand for mobile devices is given by

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The supply is given by

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a. Solve for the equilibrium price and quantity in this market, and calculate producer and consumer surplus.

b. Suppose the government offers a $100 per unit subsidy to sellers of mobile devices. Alter the equation for the inverse supply curve to reflect the subsidy.

c. With the subsidy in place, how many mobile devices will be sold? What will the price paid by buyers be? The price received by sellers?

d. What will the subsidy program cost the government? What will the net effect of the subsidy on total surplus in society be?

Appendix 3A:

The Calculus of Consumer and Producer Surplus

Just as we can use calculus to analyze the slopes of supply and demand curves, we can apply calculus to find the area under the curves, or consumer and producer surplus. Specifically, this appendix uses integration to find these areas. In the text, we were only able to solve for consumer and producer surpluses in cases in which the supply and demand curves were linear. What's powerful about integration is that it can solve for consumer and producer surplus for linear and nonlinear curves. We begin with a brief review of integration techniques before diving into the specific economic applications of integrals.

Review of Integration Methods from Calculus

Integrals are related to the derivatives we reviewed in the Math Review in that integration and differentiation are inverses of each other. If we integrate a derivative, we get back the original function, and vice versa, if we differentiate an integral, we also get back the original function[1]. The operations therefore undo each other.

It's easiest to review integration by starting with an example. Given a curve of the form
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we can solve for the area under the curve[2] between the values
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and
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Conventionally, we write this integral as

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Depending on the exact functional form, there are some basic rules for solving this integral. As in the review of derivatives in this book's Math Review, this is not a comprehensive list of rules. Instead, these are the rules that are most relevant for the topics presented in this chapter. Figure 3A.1 provides examples of a linear (panel a) and nonlinear (panel b) functional form. In both cases, integration could be used to calculate the shaded areas.

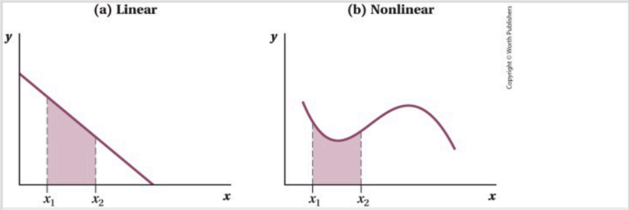

Figure 3A.1 Areas Underneath a Line Versus Areas Below a Curve

Integral of a Constant

If
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where *c* is some constant, then we can solve the integral
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This result hinges on the fact that
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is a horizontal line at
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as in Figure 3A.2. As a consequence, the area under a horizontal line between
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
and
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forms a rectangle. We know that the area of a rectangle is its base (here, the distance
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minus
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times its height
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So, the area is
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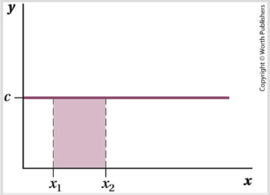

Figure 3A.2 Integral of a Constant

Power Rule for Integrals

Now take
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where *c* is again some constant. This type of curvature is common in economics, even in the shapes of some supply and demand curves. The integral of this function is
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Addition and Subtraction Rules for Integrals

Suppose
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Then the integral is intuitively easy to find: Just as with derivatives, the integral of an additive function is the integral of the first term plus the integral of the second term:

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Similarly, if
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the integral

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Consumer Surplus Using Calculus

Consumer surplus is the difference between the amount consumers would be willing to pay for a good or service and the amount they actually have to pay. Recall that we can think of total consumer surplus as the sum of differences between willingness to pay and market price at each quantity. In the chapter, we summed the area under the curve at discrete quantities (e.g., at quantities 0, 1, 2, 3, etc.). This method works for determining consumer surplus under a line, but it's not exact for nonlinear curves when geometry cannot be used to determine areas. To provide an accurate measure of consumer surplus under a nonlinear demand curve, we need to be able to measure the difference between a consumer's willingness to pay and the price at *every* point along the curve. This means we want to consider much finer fractional units than we are able to with geometric methods. This is where integration comes into play: Integration allows us to think about—and more importantly, *measure*—the total consumer surplus under a curve.

The consumer surplus calculation for the equilibrium case can be written using integral calculus as the following:

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where
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and
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are the equilibrium quantity and price, respectively, and
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is the inverse demand curve. Recall that the inverse demand curve is a demand curve written in the form of price (*P*) as a function of quantity demanded
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Note that we are evaluating the function
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Had we wanted the entire area under the demand curve, we would simply integrate
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by itself. This integral would then give us the total benefit of *Q* units of the good. But, this fails to take into account the cost of the good, so we instead want the area between demand
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and the equilibrium price
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We've also indexed this integral over the range (0,
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Why? Consumer surplus is the sum of this difference over quantities that are traded, so we will evaluate the integral between 0 and
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For an example, Figure 3.1 is reproduced from the text. Note that the demand curve illustrated is linear. In slope-intercept (or "inverse" demand) form,[3] the equation of this line is
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The consumer surplus when the market price is $3.50 equals the area of the shaded triangle. Using the formula for the area of a triangle from geometry, this is one half times the base times the height:
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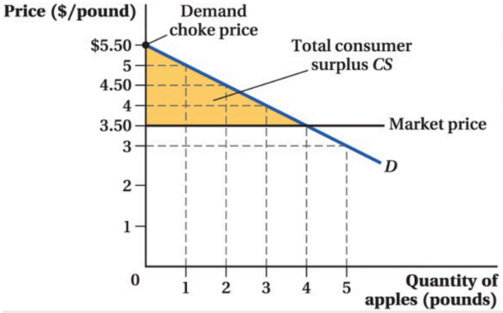

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Let's think about how we can calculate this same area using calculus. As before, we want to calculate the area under the demand curve between the quantities 0 and 4, and the prices $3.50 and $5.50. Using the rules of integration and calling
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just Q after plugging the demand curve in, the consumer surplus can be calculated as

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Note that we have substituted the inverse demand curve minus the equilibrium price into the consumer surplus formula, and because we are integrating over the quantity axis, we will evaluate this integral between the quantity values 0 and 4. To calculate this integral, recall that we can use the addition and subtraction rule of integrals to divide the calculation into two parts. We can then use the integral of a constant rule on the first part and the power rule for integrals on the second part. Specifically,

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Note that this is the same $4 consumer surplus value that we found earlier using geometry.

Producer Surplus Using Calculus

Producer surplus is the difference between the price producers actually receive and the lowest price for which they would have been willing to sell their good or service. As in the case of consumer surplus, we can calculate the producer surplus area using integral calculus. Particularly, for the equilibrium case, we want to measure the area below equilibrium price and above the supply curve. This can be calculated as

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where
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and
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are again the equilibrium quantity and price, respectively, and
Error parsing MathML: error on line 1 at column 1014: Opening and ending tag mismatch: img line 0 and a
is the inverse supply curve. Recall that the inverse supply curve[4] is a supply curve written in the form of price (P) as a function of quantity supplied
(Error parsing MathML: error on line 1 at column 707: Opening and ending tag mismatch: img line 0 and a
Because producer surplus is the difference between market price and the supply price, we want to include only the area between the equilibrium price
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and the supply curve
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and therefore we take the difference between these when setting up the integral. Because the integration again occurs over the quantity axis, we evaluate the integral between 0 and
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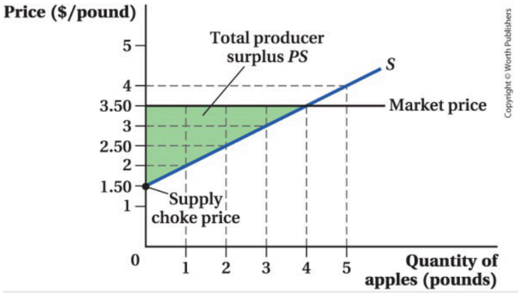

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Here, Figure 3.2 is reproduced from the text. In slope-intercept form, the linear supply curve depicted is
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Let's calculate the producer surplus using the integration techniques we reviewed above. In particular, we want to find the area under the equilibrium price and above the supply curve between the quantities 0 and 4. To do so, evaluate the integral of the

equilibrium price minus the inverse supply curve over the range 0 to 4 along the quantity axis[5]:

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Because the supply curve is linear, we can easily use geometry to confirm our solution to the producer surplus. In particular, producer surplus is the area of the triangle, or one half times the base times the height of the shaded triangle:

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It's easy to calculate the consumer and producer surpluses of this function using geometric areas. So, why did we bother with integration? As you'll see in the Figure It Out exercise that follows, integration is a method that applies to more than the specific case of linear functions. Because of this, using integrals is a universal method that we can apply to both linear and nonlinear functions.

3A.1 figure it out

Think about daily newspapers in a small Midwestern city. Suppose that supply is

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and the demand curve for daily newspapers in this second city is given by

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where quantities supplied and demanded are measured in thousands of newspapers per day, and price in this case is in cents per newspaper. Note that these supply and demand curves are nonlinear. Also note that they are already written in inverse form with prices as a function of quantity supplied and demanded, respectively.

a. Find the equilibrium price and quantity.
b. Calculate the consumer and producer surplus at the equilibrium price.

Solution:

a. Equilibrium still occurs at the intersection of supply and demand even when curves are nonlinear. Because we already have these in inverse form, we can set prices equal instead of quantities as a place to start. Doing this, we see that

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   This means that

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   Since this is measured in thousands, this corresponds to 50,000 newspapers daily.[6] We can calculate the price of a newspaper by substituting the quantity of 50 into either the supply or demand equation (or both to double-check). Doing this for the demand side, we see that

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   For the supply side, we can confirm that

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   Since price is in cents, this means that a newspaper costs $1.50 in the given market.

b. The figure below illustrates the consumer and producer surplus areas of interest where price is translated to dollars and quantity is still in thousands. Using the integral equations for consumer and producer surplus and substituting the inverse supply and demand equations as given and the equilibrium quantity and price as calculated in part (a), we can see that

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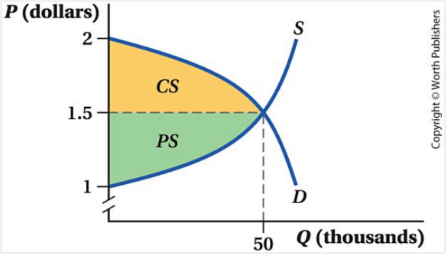
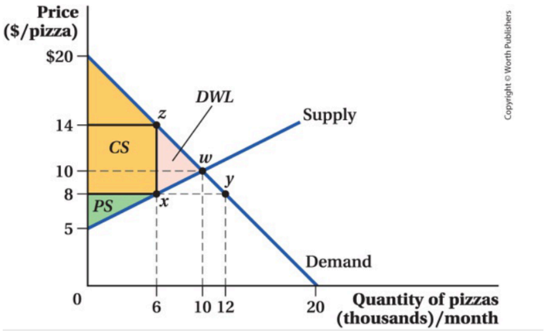
   Because prices are denominated in cents, the consumer and producer surplus areas can be interpreted as approximately $16.67 each. The fact that these work out to the same number is a coincidence of the particular shapes of the supply and demand curves in this problem. The example in the next section illustrates a case in which consumer and producer surplus values are quite different.



Distributional Effects of Intervention Using Calculus

So far we have calculated consumer and producer surpluses in a static equilibrium. However, integration methods also allow us to measure the effects of policy changes, such as the price or quantity controls described in Chapter 3, on consumer and producer surpluses. We can also take the integration one step further and use it to determine the deadweight loss of an intervention.

The basic integration formulas do not change from those we've discussed thus far. A couple of aspects of what we evaluate may change, however. First, the integral may be evaluated over a different range than over the quantities from 0 to the equilibrium quantity; for instance, you may be interested in evaluating the area over the range from 0 to a quota level. In addition, the area of interest may be between the supply or demand curve and a price other than the equilibrium price, such as a legislated price set under a price floor or ceiling or a price determined by the market after a quantity restriction (quota) is in place.



Let's reconsider the supply and demand curves for pizzas measured in pizzas per month and dollars that are illustrated in Figure 3.6 in the text:

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and

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and the intervention of a price ceiling of $8 per pizza. Suppose that we are interested in calculating consumer surplus, producer surplus, and deadweight loss after the intervention using calculus. As calculated in the text, at a price of $8, quantity traded is 6,000. We can therefore calculate consumer surplus as the area under the inverse demand curve

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and above the price of $8 between 0 and 6,000 on the quantity axis:

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Note that this is the same $54,000 per month consumer surplus after the price ceiling that is found utilizing geometry in the text. The analysis using calculus for producer surplus is similar. Now, we can calculate the area under the price of $8 and above the inverse supply curve

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between 0 and 6,000 quantity:

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This is the same $9,000 per month producer surplus after the price ceiling that is found in the text.[7]

Finally, we can calculate deadweight loss as the area under the inverse demand curve and above the inverse supply curve over the range of quantity that is not traded as the result of the intervention. In the free-market case, 10,000 pizzas are sold. In contrast, only 6,000 are traded after the price ceiling is implemented. We can therefore form the integral by taking the difference between the inverse demand and inverse supply equations (as opposed to between one of these and the equilibrium price, as we did for the consumer and producer surplus calculations). The deadweight loss calculation therefore is

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We have confirmed that deadweight loss from the pizza price ceiling is $12,000, as in the example in the chapter. The following Figure It Out feature presents an example of analyzing the distributional impact of a policy change when supply and demand curves are nonlinear.

3A.2 figure it out

Reconsider the previous Figure It Out concerning daily newspapers in a Midwestern city. The inverse demand curve for daily newspapers is again

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and inverse supply is

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Quantities supplied and demanded are measured in thousands of newspapers per day, and price is in cents per newspaper. Suppose the local government institutes a quantity regulation (quota) on newspapers at 40,000.

a. Calculate the new consumer and producer surplus values after this intervention.
b. What is the deadweight loss associated with this intervention?

Solution:

a. The consumer surplus, producer surplus, and deadweight loss areas after the intervention are illustrated in the figure on the next page. To find the new market trading price at a quantity of 40 (in thousands), we can plug 40 into the demand equation:

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   The new price therefore is $1.68. Consumer surplus is now

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   Since quantities are in thousands and prices in cents, we need to multiply the consumer and producer surplus answers by 1,000 (to account for the quantity unit of measurement) and divide by 100 (to account for the currency unit of measurement). Consumer surplus then is approximately $8,533 and producer surplus is $22,933.
b. To calculate deadweight loss, note from the figure that we are interested in the area under the demand curve and above the supply curve between a quantity of 40 and 50. We can therefore form the integral by taking the difference between the inverse demand and inverse supply equations (as opposed to between one of these and the equilibrium price, as we did for the consumer and producer surplus calculations). We then want to evaluate this integral between quantity levels of 40 and 50. In other words, we will evaluate this integral over the transactions that would occur in the absence of intervention but that do not occur when the quota is put in place:

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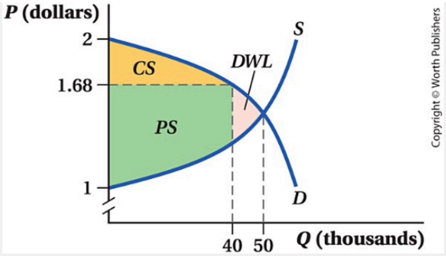
   Deadweight loss therefore is approximately $1,867 in dollar terms after accounting for the units of measurement as above.



Problems

1. Suppose that the demand curve for a particular high-end designer purse in a medium-sized city is given by

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   and supply is

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   where price is in dollars and quantity is in numbers of purses.

   a. Find the equilibrium price and quantity.

   b. Calculate the consumer and producer surplus at the equilibrium price.

2. Suppose that the supply and demand curves for the designer purse in Problem 1 are given as above. Further suppose that the wife of a local politician owns one of these purses and wants to make sure that its particular style remains relatively exclusive. She convinces her husband to institute a quantity regulation (quota) at 30.

   a. Calculate the new consumer and producer surplus values after this intervention.

b. What is the deadweight loss associated with the quota?

c. Suppose the local government institutes a price regulation (floor) at $591 instead of the quota. Calculate the new consumer and producer surplus values after this intervention.

d. What is the deadweight loss associated with the price floor?

e. Comparing your answers for the price floor in parts (c) and (d) to your solutions for the quota in parts (a) and (b), what can you deduce about the relationship between price and quantity public policy instruments in this case?

3. Suppose that the demand curve for a restaurant chain's new burger is given by
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and supply is
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where price is in dollars and quantity is in hundred thousands of burgers.

    a. Find the equilibrium price and quantity.

    b. Calculate the consumer and producer surplus at the equilibrium price.

    c. Suppose that due to pressure from groups campaigning for increased availability of restaurant food for the poor, the federal government sets a price ceiling of $5.50. Calculate the new consumer and producer surplus.

    d. Calculate the deadweight loss associated with the price ceiling regulation.

CHAPTER 4

Consumer Behavior

4.1 The Consumer's Preferences and the Concept of Utility
4.2 Indifference Curves
4.3 The Consumer's Income and the Budget Constraint
4.4 Combining Utility, Income, and Prices: What Will the Consumer Consume?
4.5 Conclusion
Appendix 4A The Calculus of Utility Maximization and Expenditure Minimization
Appendix 4B The Mathematics of Utility Functions

The Korean electronics company Samsung adds new features to its Galaxy phone each year in order to increase sales. The features Samsung will include depend a great deal on consumer preferences: Is battery life more important than memory? What kind of camera do consumers want? How much are they willing to pay for a larger screen? Only by determining the answers to these questions can Samsung succeed in the marketplace.

This chapter is about one key question: How do consumers decide which products (and how much of each) to buy? The answer to this question is the building block for the demand curve in the basic supply and demand model, and understanding consumer behavior is a powerful tool with many applications.

We begin the chapter by discussing the nature of consumers' *preferences* (what they like and don't like) and how economists use the concepts of *utility* (a measure of a consumer's well-being) and *utility functions* to summarize their preferences. In addition, this chapter explores a concept you will continue to encounter: *constrained* *optimization*. When facing decisions, consumers try to do the best they can (to *optimize*) given the *constraints* they face, such as the amount of money they have to spend. To arrive at choices that will make them happiest, consumers must make tradeoffs in the smartest way possible. Such tradeoffs depend on a consumer's preferences, the amount of income the consumer has to spend, and the prices of goods. We combine these ideas to analyze how consumers behave: why people buy less of something when its price rises (i.e., why demand curves slope down), why people consume different goods as they grow wealthier rather than a lot more of the same things, and so on.

The set of techniques we will use to analyze consumers' constrained optimization problems will appear repeatedly, with slight modifications, throughout this book and in any economics courses you take in the future. Learn the techniques here and you can use them forever.

4.1 The Consumer's Preferences and the Concept of Utility

Consumers' preferences underlie every decision they make. Economists think of consumers as making rational choices about what they like best, given the constraints they face.

Assumptions about Consumer Preferences

Consumers make many choices every day about what to buy and what not to buy. These choices involve many different goods: Buy a giant bag of Twizzlers and walk home, or buy a bus ticket and leave a sweet tooth unsatisfied? Buy a new video game or get your car's oil changed? To understand how consumers form their preferences for all the possible goods and services they can buy, we need to make some simplifying assumptions. Specifically, we assume that all decisions about what to buy share four properties:

1. **Completeness and rankability.** We assume that consumers can make comparisons across all possible sets of goods. Economists use the term **consumption bundle** (or just *bundle*) to describe any set of goods or services a consumer considers purchasing. The assumption means that, given any two bundles, an individual consumer can decide which they prefer (or whether they are *indifferent,* meaning they like them the same). This assumption is important because it means that we can apply economic theory to any bundle of goods we want to discuss. Whether the bundle includes sapphires and SUVs or movies, modern art, and marshmallows, the consumer can decide which bundle they like better. Note, however, that this assumption does not tell us what kinds of bundles the consumer will like more than others. It just implies they are able to determine if one is better than the other.
2. **For most goods, more is better than less (or at least more is no worse than less).** In general, more of a good thing is good. If we like a car that will better ensure our safety in a crash, we would like that same car even more if it were even safer.[1]

3. **Transitivity.** For any three bundles of goods (call them *A*, *B*, and *C*), if a consumer prefers *A* to *B* and also prefers *B* to *C*, then that consumer prefers *A* to *C*. If you prefer apples to oranges, and you prefer oranges to bananas, then transitivity implies that you must also prefer apples to bananas. Note that, as always, we are holding everything else constant when making these comparisons. Transitivity does *not* mean that you prefer apples to bananas in all situations—only that, at a given moment, you prefer apples to bananas. Transitivity imposes logical consistency on preferences.
4. **The more a consumer has of a particular good, the less that consumer is willing to give up of something else to get even more of that good.** The idea behind this assumption is that consumers like variety. If you like doughnuts and haven't had any lately, you might be willing to give up a lot to get some. You might be willing to pay a high price for a donut, wait in a long line for a donut, or trade away your last carton of milk for a good donut. On the other hand, if you've just polished off eight donuts in a row, you wouldn't pay as much for the ninth donut as you did for that first one.[2]

consumption bundle
A set of goods or services a consumer considers purchasing.

The Concept of Utility

Given these assumptions about preferences, we could create a list of all the consumer's preferences between any possible bundles for every decision. But because such a list would include billions of possible bundles, it would be basically useless as a decision aid. Instead, economists use the concept of utility and a mathematical description called a utility function to describe preferences more simply.

- **Utility** is a measure of how satisfied a consumer is. For practical purposes, you can think of utility as a fancy word for happiness or well-being. It is important to realize that utility is *not* a measure of how rich a consumer is. Income may affect utility, but it is just one of many factors that do so.
- A **utility function** mathematically describes the relationship between what consumers actually consume and their level of well-being. A function is a mathematical relationship that links a set of inputs to an output. For instance, if you combine the inputs eggs, flour, sugar, vanilla, butter, frosting, and candles in just the right way, you end up with the output of a birthday cake. In consumer behavior, the inputs to a utility function are the different things that can give a person utility. Examples of inputs to the utility function include traditional goods and services like cars, candy bars, health club memberships, and airplane rides. But there are many other types of inputs to utility as well, including scenic views, a good night's sleep, spending time with friends, and the pleasure that comes from giving to charity. The output of the utility function is the consumer's utility level. By mapping the various bundles a consumer considers to an explicit measure of that same consumer's level of well-being, a utility function gives us a concise way to rank a consumer's bundles.

utility
A measure of how satisfied a consumer is.

utility function
A mathematical function that describes the relationship between what consumers actually consume and their level of well-being.

Ivan/Moment/Getty Images

A scenic view is just one type of utility input that increases consumer well-being.

Utility functions can take a variety of mathematical forms. Let's look at the utility someone enjoys from consuming combinations of Junior Mints and KitKats. Generically, we can write this utility level as

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where

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is the utility function and *J* and *K* are, respectively, the number of Junior Mints and KitKats the consumer eats. An example of a specific utility function for this consumer is

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In this case, the consumer's level of utility equals the product of the number of Junior Mints and KitKats they eat. But it could instead be that the consumer's utility equals the total number of Junior Mints and KitKats eaten. In that case, the utility function is

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Yet another possibility is that the consumer's utility is given by

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Because the exponent on Junior Mints (0.7) is larger than that on KitKats (0.3), this utility function implies that a given percentage increase in Junior Mints consumed will raise utility more than the same percentage increase in KitKats.

These are just a few examples from the large variety of possible utility functions we could imagine consumers having for these or any other combination of goods. At this point in our analysis of consumer behavior, we don't have to be too restrictive about the form any particular utility function takes, and it's sort of arbitrary to choose one here. Just remember, utility functions represent consumers' preferences. They are supposed to represent what people actually like. And they have to conform to our four assumptions about preferences (rankability and completeness, more is better, transitivity, and variety is important).

Marginal Utility

One of the most important concepts related to utility functions is **marginal utility**, the extra utility a consumer receives from a 1-unit increase in consumption.[3] Each good in a utility function has its own marginal utility. Using the Junior Mints and KitKats utility function, for example, the marginal utility of Junior,

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would be

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where

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is the small (1-unit) change in the number of Junior Mints the consumer eats and

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is the change in utility they get from doing so. Likewise, the marginal utility of consuming KitKats is given by

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marginal utility
The extra utility a consumer receives from a 1-unit increase in consumption.

Later in this chapter, we see that marginal utility is the key to understanding the consumption choices a person makes.

Utility and Comparisons

One important point about utility and the four assumptions about preferences with which we started our discussion is that they allow us to rank all bundles of goods for a particular consumer, but they do not allow us to determine how much more a consumer likes one bundle than another. In mathematical terms, we have an *ordinal* ranking of bundles (we can line them up from best to worst), but not a *cardinal* ranking (which would allow us to say by exactly how much a consumer prefers one bundle to another). We say this because the units with which we measure utility are essentially arbitrary and made up.

An example will make this clearer. Let's say we define our measurement of consumer utility in a unit we call a "util." And let's say we have three bundles: *A*, *B*, and *C*, and a consumer who likes bundle *A* the most and bundle *C* the least. We might then assign these three bundles values of 8, 7, and 6 utils, respectively. The difficulty is that we just as easily could have defined consumer utility in terms of "bootles" and assigned the bundles values of 8, 7, and 2 bootles (or 19, 17, and 16 tootles; you get the idea), and this would still perfectly describe the situation. You can say that you like something better, but how can you describe how happy it makes you, according to some objective measuring tape? Because there is no real-world unit of measure, like a dollar, gram, or inch, with which to measure utility, we can shift, stretch, or squeeze a utility function without altering any of its observable implications, as long as we don't change the ordering of preferences over bundles.[4] With ordered rankings, we can still provide answers to the important questions about how consumers behave and how this behavior results in a downward-sloping demand curve.

The thing we can't do, though, is make *interpersonal comparisons* of utility—that is, we can't compare one person's utility to some other person's. We can say Person A and Person B both like KitKats more than Junior Mints, but we can't say who likes KitKats more and hence should purchase all of them, or if we should divide the candies evenly. Questions like this relate to what is called **welfare economics**, the area of economics concerned with the economic well-being of society as a whole, which we discuss later in this book. For now, however, we focus on the preferences of one consumer at a time.

welfare economics
The area of economics concerned with the economic well-being of society as a whole.

Just as important as the assumptions we make when analyzing utility functions are the assumptions that we do *not* make. For one, we do not impose particular preferences on consumers. People like what they like. Some people like ferrets more than dogs as pets. As long as they follow the four preference assumptions, we don't make judgments on what is valuable. Preferences are just a description of what makes people happy. We also don't require that preferences remain constant over time. Someone may prefer sleeping to seeing a movie tonight, but tomorrow indicate the opposite preference.

The concepts of utility and utility functions are general enough to account for a consumer's preferences over any number of goods and the various bundles into which they can be combined. As we build our model of consumer behavior, however, we focus on a simple case where a consumer buys a bundle with only two goods, though the ideas still apply in more complicated situations.

4.2 Indifference Curves

As we discussed in the previous section, the right way to think about utility is in relative terms; that is, in terms of whether one bundle of goods provides more or less utility to a consumer compared to another bundle. An especially good way of understanding utility is to consider when a consumer is **indifferent**, the special case in which a consumer derives the same level of utility from each of two or more consumer bundles.

indifferent
The special case in which a consumer derives the same level of utility from each of two or more consumption bundles.

Appendix 4B explores the mathematics of monotonic transformations of utility functions.

Consider the case of renting an apartment where there are two "goods" you must choose between: the size in square feet and the number of friends living in the same building. Michaela wants a large apartment, but also wants to be able to easily see her friends. **Figure 4.1a** graphs three bundles (apartments) that offer Michaela the same utility from different size/friend combinations: a 750-square-foot apartment in a building where 5 of her friends live; a 500-square-foot one in a building where 10 friends reside; and a more generous-sized, 1,000-square-foot one for which Michaela would be willing to make do with only 3 friends nearby. These are not the only three bundles that would give Michaela the same level of utility; there are many different bundles that will accomplish this goal—an infinite number of bundles, in fact, if we ignore that it might not make sense to have access to a fraction of a friend (or maybe it does?).

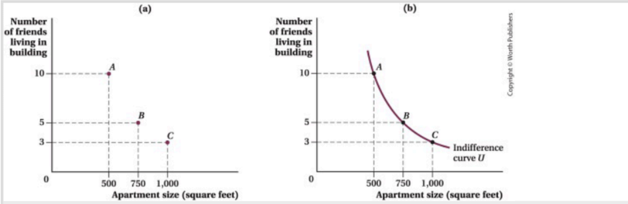

Figure 4.1 Building an Indifference Curve

(a) Because Michaela receives utility from both the number of friends in her apartment building and the square footage of her apartment, she is equally happy with 10 friends in her building and a 500-square-foot apartment, or 5 friends in her building and a 750-square-foot apartment. Likewise, she is willing to trade off 2 more friends in her building (leaving her with 3) to have a 1,000-square-foot apartment. These are three of many combinations of friends in her building and apartment size that make her equally happy.

(b) An indifference curve connects all bundles of goods that provide a consumer with the same level of utility. Bundles *A*, *B*, and *C* provide the same satisfaction for Michaela. Thus, the indifference curve represents Michaela's willingness to trade off between friends in her apartment building and the square footage of her apartment.

The combination of all the different bundles of goods that give a consumer the same utility is called an **indifference curve**. In Figure 4.1b, we draw Michaela's indifference curve, which includes the three points shown in Figure 4.1a. Notice that it contains not just the three bundles we discussed, but many other combinations of square footage and friends in the building. Also notice that it always slopes down: Every time a friend moves from Michaela's building, she would need more square footage to remain indifferent. (Equivalently, we could say any apartment with less space would require more friends in the building to keep her equally well off.)

indifference curve
The combination of all the different consumption bundles that provide a consumer with the same utility.

For each level of utility, there is a different indifference curve. **Figure 4.2** shows two of Michaela's indifference curves. Which corresponds to the higher level of utility? The easiest way to figure this out is to think like Michaela. One of the points on the indifference curve

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represents the utility Michaela would get if she had 5 friends in her building and a 500-square-foot apartment. Curve
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includes a bundle with the same number of friends and a 1,000-square-foot apartment. By our “more is better” assumption, indifference curve
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must make Michaela better off. We could have instead held the apartment’s square footage constant and asked which indifference curve had more friends in the building, and we would have found the same answer. Any indifference curve that is closer to the origin (zero units of both goods) than another curve has a lower utility (we learn below that they can’t cross). Michaela’s utility is higher at every point on
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than at any point on

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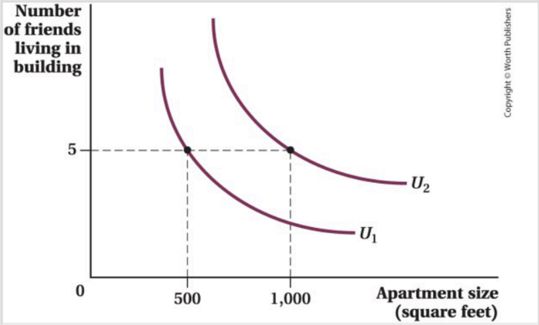

Figure 4.2 A Consumer’s Indifference Curves

Each level of utility has a separate indifference curve. Because we assume that more is preferred to less, an indifference curve lying to the right and above another indifference curve reflects a higher level of utility. In this graph, the combinations along curve
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provide Michaela with a higher level of utility than the combinations along curve
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the curve closer to the origin (zero units of both goods). Michaela will be happier with a 1,000-square-foot apartment than a 500-square-foot apartment, holding the number of friends living in her building equal at 5.

Characteristics of Indifference Curves

Generally speaking, the positions and shapes of indifference curves can tell us a lot about an individual consumer’s behavior and decisions. However, our four assumptions about utility functions put some restrictions on the shapes that indifference curves can take.

1. **We can always draw indifference curves.** The first assumption, completeness and rankability, means that we can always draw indifference curves: All bundles have a utility level, and we can rank them.
2. **We can figure out which indifference curves have higher utility levels and why they slope downward.** The “more is better” assumption implies that we can look at a set of indifference curves and figure out which ones represent higher utility levels. This can be done by holding the quantity of one good fixed and seeing which curves have larger quantities of the other good. This is exactly what we did when examining Figure 4.2. The assumption also implies that indifference curves never slope upward. If they did, this would mean that a consumer was indifferent between a particular bundle and another bundle with more of *both* goods. There’s no way this can be true if more is always better.
3. **Indifference curves never cross.** The transitivity property implies that indifference curves for a given consumer can never cross. To see why, suppose our apartment-hunter Michaela’s hypothetical indifference curves intersect with each other, as shown in **Figure 4.3**. The “more is better” assumption implies Michaela prefers bundle *E* to bundle *D*, because *E* offers both more square footage and more friends in her building than does *D*. Now, because *E* and *F* are on the same indifference curve
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Michaela’s utility from consuming either bundle must be the same by definition. And because bundles *F* and *D* are on the same indifference curve

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she must also be indifferent between *those* two bundles. But here's the problem. Putting this all together means she's indifferent between *E* and *D* because each makes her just as well off as *F*. We know that can't be true. After all, she must like *E* more than *D* because it has more of both goods. Something has gone wrong: We violated the transitivity property by allowing the indifference curves to cross. Intersecting indifference curves imply that the same bundle (the one located at the intersection) offers two different utility levels, which can't be the case.

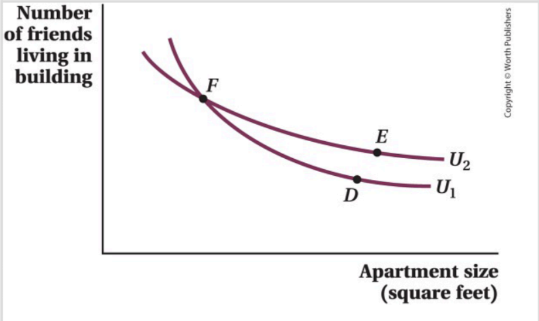

Figure 4.3 A Consumer's Indifference Curves Cannot Cross

Indifference curves cannot intersect. Here, Michaela would be indifferent between bundles *D* and *F* and also indifferent between bundles *E* and *F*. The transitivity property would therefore imply that she must also be indifferent between bundles *D* and *E*. But this can't be true, because more is preferred to less, and bundle *E* contains more of both goods (more friends in her building and a larger apartment) than *D*.

4. **Indifference curves are convex to the origin (i.e., they bend toward the origin in the middle and away at the edges).** The fourth assumption of utility—the more you have of a particular good, the less you are willing to give up of something else to get even more of that good—implies something about the way indifference curves are curved. Specifically, it implies they will be convex to the origin; that is, the middle will bend in toward the origin as if the origin is tugging on the indifference curve, trying to pull it in.

   To see what this curvature means in terms of a consumer's behavior, think about what the slope of an indifference curve means. Again, we'll use Michaela as an example. In **Figure 4.4**, at point *A* where the indifference curve is steep, Michaela is willing to give up a lot of friends to get a few more square feet, because she already has a lot of friends in the building but little space. At point *B* where the indifference curve is relatively flat, Michaela has a large apartment but few friends around, so she now would require a large amount of space in return for a small reduction in friends to be left equally satisfied.

Because tradeoffs between goods generally depend on how much of each good a consumer would have in a bundle, indifference curves are convex to the origin. Except for some extreme cases where the indifference curves become completely flat lines or bend all the way into right angles (both of which we will discuss later in the chapter), all the indifference curves we draw will have this shape.

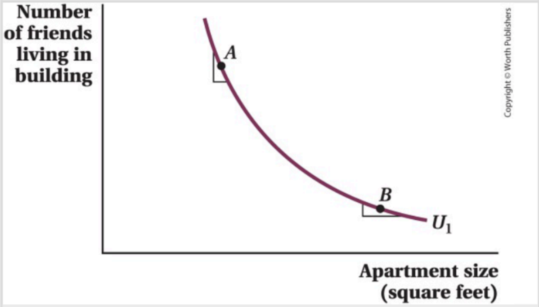

Figure 4.4 Tradeoffs along an Indifference Curve

If the indifference curve is steep, as it is at point *A*, Michaela is willing to give up a lot of friends to get just a few more square feet of apartment space. It isn't just coincidence that she's willing to make this tradeoff at a point where she already has a lot of friends in the building but a very small apartment. Because she already has a lot of one good (friends in the building), she is willing to relinquish quite a bit of it in order to gain more of the other good (apartment size) she doesn't have much of. On the other hand, where the indifference curve is relatively flat, as it is at point *B*, the tradeoff between friends and apartment size is reversed. At *B*, the apartment is already big, but Michaela has few friends around, so she now needs to receive a great deal of extra space in return for a small reduction in friends to be left as well off.

The Marginal Rate of Substitution

Indifference curves are all about tradeoffs: How much of one good will a consumer give up to get a little bit more of another good? The slope of the indifference curve exactly captures this tradeoff idea. Economists have a particular name for the slope of an indifference curve: the **marginal rate of substitution of *X* for *Y***
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the rate at which a consumer is willing to trade off or substitute exactly 1 unit of good *X* (the good on the horizontal axis) for more of good *Y* (the good on the vertical axis) and feel equally well off, with utility held constant:

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marginal rate of substitution of *X* for *Y*
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The rate at which a consumer is willing to trade off one good (the good on the horizontal axis, *X*) for another (the good on the vertical axis, *Y*) and still be left equally well off.

(A technical note: We put a negative sign in front of the slope so that we can refer to
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as a positive number. The slope of the indifference curve will be a negative number on its own because the curve slopes downward.) The word "marginal" indicates that we are talking about the tradeoffs associated with small changes in the composition of the bundle of goods—that is, changes at the margin. It makes sense to focus on marginal changes because the willingness to substitute between two goods depends on where the consumer is located on their indifference curve.

Figure 4.5 shows two points on an indifference curve that reflects Sarah's preferences for food during one month. She lives on lattes and burritos. At point *A*, the indifference curve is very steep, meaning Sarah will give up multiple burritos to get one more latte. Here, the marginal rate of substitution is relatively high. The reverse is true at point *B*. At that point, Sarah will trade multiple lattes for one more burrito, so the marginal rate of substitution is relatively low. As a result of this change in Sarah's willingness to trade as we move along the indifference curve, the indifference curve is convex to the origin (the middle bends toward the origin).

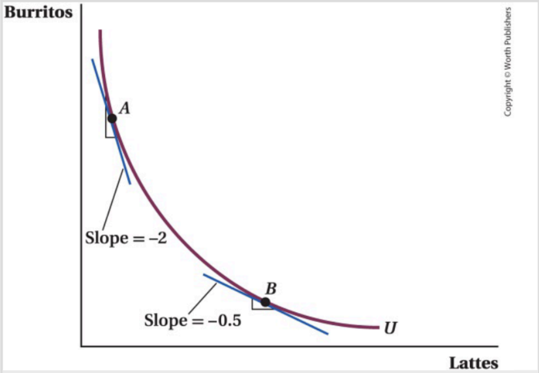

Figure 4.5 The Slope of an Indifference Curve Is the Marginal Rate of Substitution

The marginal rate of substitution measures the willingness of a consumer to trade one good for the other. It is measured as the negative of the slope of the indifference curve at any point. At point *A*, the slope of the curve is
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and the MRS is 2. This implies that, for that given bundle, Sarah is willing to trade 2 burritos to receive 1 more latte. At point *B*, the slope is
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and the MRS is 0.5. At this point, Sarah is only willing to give up 0.5 burritos to get another latte.

This shift in the willingness to substitute one good for another along an indifference curve seems confusing. You might be more familiar with thinking about the slope of a straight line (which is constant) than the slope of a curve (which varies at different points along the curve). Also, how can preferences differ along an indifference curve? After all, a consumer isn't supposed to prefer one point on an indifference curve over another, but now we're saying the consumer's relative tradeoffs between the two goods change as one moves along the curve. Let's address each of these issues in turn.

First, the slope of a curve, unlike a straight line, depends on where on the curve you are measuring the slope. To measure the slope of a curve at any point, draw a straight line that just touches the curve (but does not pass through it) at that point but nowhere else. This point where the line (called a tangent) touches the curve is called a tangency point. The slope of the line is the slope of the curve at the tangency point. The tangents that have points *A* and *B* as tangency points are shown in Figure 4.5. The slopes of those tangents are the slopes of the indifference curve at those points. At point *A*, the slope is

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indicating that at this point Sarah would require 2 more burritos to forgo 1 latte. At point *B*, the slope is

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indicating that at this point Sarah would require only half of a burrito to be willing to give up a latte. Second, although it's true that a consumer is indifferent between any two points on an indifference curve, that doesn't mean her relative preference for one good versus another is constant all along the curve. As we discussed above, Sarah's relative preference changes with the number of units of each good she already has.

Despite an intimidating name, the marginal rate of substitution makes sense. It tells us the relative value that a consumer places on obtaining one more unit of the good on the horizontal axis, in terms of the good on the vertical axis. You make this kind of decision all the time. Whenever you order off a menu at a restaurant, choose whether to fly or drive home for the holidays, or decide what brand of jeans to buy, you're evaluating relative values. As we see later in this chapter, when prices are attached to goods, the consumer's decision about what to consume boils down to a comparison of the relative value they place on two goods and the goods' relative prices.

The Marginal Rate of Substitution and Marginal Utility

Consider point *A* in Figure 4.5. The marginal rate of substitution at point *A* equals 2 because the slope of the indifference curve at that point is

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In words, this means that in return for 1 more latte, Sarah is willing to give up 2 burritos. At point *B*, the marginal rate of substitution is 0.5, which implies that Sarah would sacrifice only half of a burrito for 1 more latte (or equivalently, she would sacrifice 1 burrito for 2 lattes).

This change in the willingness to substitute between goods at the margin occurs because the benefit a consumer gets from another unit of a good falls with the number of units they already have. If you have already amped up on caffeine after drinking 6 lattes but haven't eaten all day, you'd forgo lots of lattes to get a burrito.

Another way to see all of this is to think about the change in utility

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created by starting at some point on an indifference curve and moving a short distance along it. Suppose we begin at point *A* and then move just a bit down and to the right along the curve. We can write the change in utility created by that move as the marginal utility of lattes (the extra utility the consumer gets from a 1-unit increase in lattes,

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times the increase in the number of lattes due to the move

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plus the marginal utility of burritos

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times the decrease in the number of burritos

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due to the move. The change in utility is

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where

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and

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are the marginal utilities of lattes and burritos at point *A*, respectively. Here's the key: Because we're moving along an indifference curve (so utility is constant at every point on it), *the total change in utility from the move must be zero*. If we set the equation equal to zero, we get

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Rearranging the terms slightly will allow us to discern an important relationship:

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Notice that the left-hand side of this equation equals the negative of the slope of the indifference curve, or

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We now can see a very significant connection: The

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between two goods at any point on an indifference curve equals the inverse ratio of those two goods' marginal utilities:

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Appendix 4A, located at the end of this chapter, uses calculus to derive the relationship between the marginal rate of substitution and marginal utilities.

In more basic terms,

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shows the point we have emphasized from the beginning: You can tell how much people value something by their choices of what they would be willing to give up to get it. The rate at which they give things up reveals the marginal utility of the goods.

We've now established the connection between a consumer's preferences for two goods and the slope of her indifference curves (the

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They are the same thing. An indifference curve reveals a consumer's willingness to trade one good for another, or each good's relative marginal utility. We can flip this relationship on its head to see what the shapes of indifference curves tell us about consumers' utility functions. In the next two sections, we discuss two key characteristics of an indifference curve: how steep it is, and how curved it is.

The Steepness of Indifference Curves

Figure 4.6 presents two sets of indifference curves reflecting two different sets of preferences for concert tickets and vinyl records. In panel a, the indifference curves are steep. In panel b, they are flat. (These two sets of indifference curves have the same degree of curvature so we don't confuse steepness with curvature.) When indifference curves are steep, as in panel a, consumers are willing to give up a lot of the good on the vertical axis (concert tickets) to get a small additional amount of the good on the horizontal axis (vinyl records). The opposite is true in panel b, which shows flatter indifference curves. These relationships are just another way of restating the concept of the

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that we introduced earlier.

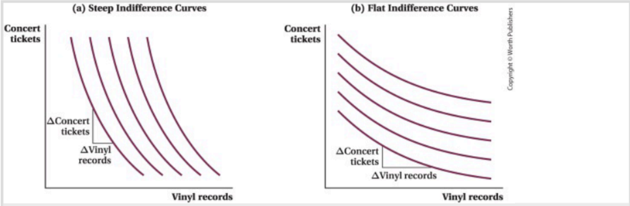

Figure 4.6 Steepness of Indifference Curves

Because the MRS measures the willingness of the consumer to trade one good for another, we can tell a great deal about preferences by examining the shapes of indifference curves. (a) Indifference curves that are relatively steep indicate the consumer is willing to give up a large quantity of the good on the vertical axis to get another unit of the good on the horizontal axis. Here, the consumer is willing to give up a lot of concert tickets for some additional vinyl records. (b) Relatively flat indifference curves imply that the consumer would require a large increase in the good on the horizontal axis to give up a unit of the good on the vertical axis. The consumer with flat indifference curves will give up a lot of records for one additional concert ticket.

figure it out 4.1

Mariah consumes music downloads (*M*) and concert tickets (*C*). Her utility function is given by Error parsing MathML: error on line 1 at column 1143: Opening and ending tag mismatch: img line 0 and annotation-xml, where Error parsing MathML: error on line 1 at column 864: Opening and ending tag mismatch: img line 0 and annotation-xml and Error parsing MathML: error on line 1 at column 917: Opening and ending tag mismatch: img line 0 and annotation-xml.

a. Write an equation for Error parsing MathML: error on line 1 at column 933: Opening and ending tag mismatch: img line 0 and annotation-xml.
b. Would bundles of Error parsing MathML: error on line 1 at column 1401: Opening and ending tag mismatch: img line 0 and annotation-xml and Error parsing MathML: error on line 1 at column 1401: Opening and ending tag mismatch: img line 0 and annotation-xml be on the same indifference curve? How do you know?
c. Calculate Error parsing MathML: error on line 1 at column 933: Opening and ending tag mismatch: img line 0 and annotation-xml when Error parsing MathML: error on line 1 at column 687: Opening and ending tag mismatch: img line 0 and annotation-xml and Error parsing MathML: error on line 1 at column 687: Opening and ending tag mismatch: img line 0 and annotation-xml and when Error parsing MathML: error on line 1 at column 687: Opening and ending tag mismatch: img line 0 and annotation-xml and Error parsing MathML: error on line 1 at column 687: Opening and ending tag mismatch: img line 0 and annotation-xml.
d. Based on your answers to question b, are Mariah's indifference curves convex? (*Hint:* Does Error parsing MathML: error on line 1 at column 933: Opening and ending tag mismatch: img line 0 and annotation-xml fall as *M* rises?)

Solution:

a. We know that the marginal rate of substitution Error parsing MathML: error on line 1 at column 933: Opening and ending tag mismatch: img line 0 and annotation-xml equals Error parsing MathML: error on line 1 at column 1065: Opening and ending tag mismatch: img line 0 and annotation-xml. We are told that Error parsing MathML: error on line 1 at column 864: Opening and ending tag mismatch: img line 0 and annotation-xml and Error parsing MathML: error on line 1 at column 917: Opening and ending tag mismatch: img line 0 and annotation-xml. Thus, Error parsing MathML: error on line 1 at column 2403: Opening and ending tag mismatch: img line 0 and annotation-xml.
b. For bundles to lie on the same indifference curve, they must provide the same level of utility to the consumer. Therefore, we need to calculate Mariah's level of utility for the bundles of Error parsing MathML: error on line 1 at column 1401: Opening and ending tag mismatch: img line 0 and annotation-xml and Error parsing MathML: error on line 1 at column 1401: Opening and ending tag mismatch: img line 0 and annotation-xml:

   When Error parsing MathML: error on line 1 at column 687: Opening and ending tag mismatch: img line 0 and annotation-xml and Error parsing MathML: error on line 1 at column 687: Opening and ending tag mismatch: img line 0 and annotation-xml, Error parsing MathML: error on line 1 at column 2951: Opening and ending tag mismatch: img line 0 and annotation-xml

   When Error parsing MathML: error on line 1 at column 687: Opening and ending tag mismatch: img line 0 and annotation-xml and Error parsing MathML: error on line 1 at column 687: Opening and ending tag mismatch: img line 0 and annotation-xml, Error parsing MathML: error on line 1 at column 2948: Opening and ending tag mismatch: img line 0 and annotation-xml

   Each bundle provides Mariah with the same level of utility, so they must lie on the same indifference curve.
c. and d. To determine if Mariah's indifference curve is convex, we need to calculate Error parsing MathML: error on line 1 at column 933: Opening and ending tag mismatch: img line 0 and annotation-xml at both bundles. Then we can see if Error parsing MathML: error on line 1 at column 933: Opening and ending tag mismatch: img line 0 and annotation-xml falls as we move down along the indifference curve (i.e., as *M* increases and *C* decreases):

   When Error parsing MathML: error on line 1 at column 687: Opening and ending tag mismatch: img line 0 and annotation-xml

and

Error parsing MathML: error on line 1 at column 687: Opening and ending tag mismatch: img line 0 and annotation-xml,

Error parsing MathML: error on line 1 at column 2859: Opening and ending tag mismatch: img line 0 and annotation-xml

When

Error parsing MathML: error on line 1 at column 687: Opening and ending tag mismatch: img line 0 and annotation-xml

and

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Error parsing MathML: error on line 1 at column 2483: Opening and ending tag mismatch: img line 0 and annotation-xml

These calculations reveal that, holding utility constant, when music downloads rise from 2 to 4, the Error parsing MathML: error on line 1 at column 933: Opening and ending tag mismatch: img line 0 and annotation-xml rises from 0.25 to 1. This means that as Mariah consumes more music downloads and fewer concert tickets, she actually becomes *more* willing to trade concert tickets for additional music downloads! Most consumers would not behave in such a way. This means that the indifference curve becomes steeper as *M* rises, not flatter. In other words, this indifference curve will be concave to the origin rather than convex, violating the fourth characteristic of indifference curves listed above.

Application: Indifference Curves for Breakfast Cereal

Many people can't start the day without a bowl of cereal. Surveys suggest that more than 90% of families in the United States buy breakfast cereal during the course of a year, and total annual cereal sales exceed $10 billion. Hundreds of different kinds of cereal fill grocery store shelves throughout North America.

Economists have studied the cereal market and how people decide what cereal to buy. Their findings give us some direct estimates of indifference curves.

Economist Aviv Nevo once looked at 25 leading cereal brands in 65 cities.[5] He gathered information on the characteristics of the cereals in terms of sugar, calories, fat, fiber, mushiness, and so on, and treated each cereal like a bundle of these characteristics. (An analysis of products using their attributes is called *hedonic analysis,* and economists have done hedonic analyses of cars, computers, houses, and many other kinds of products.)

Nevo computed the implied marginal rates of substitution for these different product attributes by comparing the demand for different cereals at different prices. Let's take his results on two of the "goods" people consume when buying cereal—sugar and fiber. Both have a value and both have a cost, so consumers must make tradeoffs between them when choosing what cereal to buy.

We can use Nevo's results to compute a direct estimate of the MRS of fiber for sugar for different kinds of people. Holding everything else equal, Nevo found that a 50-year-old consumer (let's call him Ricardo) with an income one-third above the national average has an MRS of 1.24. To remain indifferent between his current cereal and a new cereal with 1 less gram of fiber, Ricardo requires 1.24 grams of additional sugar in the new cereal (to sweeten the deal). He clearly likes taking in fiber at breakfast.

The MRS differs for other kinds of people, however. A 20-year-old consumer (let's call him David) with income about one-third below the national average has a much lower taste for fiber. According to Nevo's measurements, David's MRS of fiber for sugar is only 0.57. For David to remain indifferent between his current cereal and a new cereal with 1 less gram of fiber, he requires only 0.57 grams of additional sugar. He likes sugar more and is thus more willing to give up fiber to get it.

We know that the MRS of fiber for sugar is the ratio of marginal utilities, Error parsing MathML: error on line 1 at column 1315: Opening and ending tag mismatch: img line 0 and annotation-xml. Ricardo's ratio is greater than David's because he is willing to give up more sugar in exchange for fiber. Ricardo's indifference curves (**Figure 4.7a**), when drawn with fiber on the horizontal axis and sugar on the vertical axis, are therefore steeper than David's indifference curves (Figure 4.7b). Nevo found that something about 50-year-olds makes them more likely to prefer high-fiber cereals than high-sugar cereals; 20-year-olds prefer just the opposite. Because they have different tastes in cereal, the marginal rates of substitution and, in turn, the slopes of the indifference curves look different for older adults and younger adults.

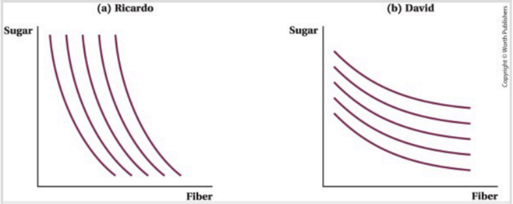

Figure 4.7 Older and Younger Adults' Preferences for Breakfast Cereal

Fifty-year-old Ricardo (a) has a greater MRS of fiber for sugar (and steeper indifference curves) than 20-year-old David. (b) Accordingly, Ricardo is more likely to want his fiber and less willing to trade fiber content for sugar. Because David has a lower MRS of fiber for sugar, he is more willing to give up fiber for sugar. As a result, his indifference curves are flatter.

This result probably also explains why the people buying Kellogg's Honey Smacks (with 20 grams of sugar and 1.3 grams of fiber per cup) likely aren't the same people purchasing Kashi's GoLean (with 6 grams of sugar and 10 grams of fiber per cup).

The Curvature of Indifference Curves: Substitutes and Complements

Appendix 4B looks at the relationship between the utility function and the shape of indifference curves.

The steepness of an indifference curve tells us the rate at which a consumer is willing to trade one good for another. The curvature of an indifference curve also has a meaning. If indifference curves between two goods are almost straight, as in **Figure 4.8a**, a consumer (let's call him Syed) is willing to trade about the same amount of the first good (here, decaf coffees) to get the same amount of the second good (decaf lattes), regardless of whether he has a lot of lattes relative to coffees or vice versa. Stated in terms of the marginal rates of substitution, the MRS of coffees for lattes doesn't change much as we move along the indifference curve. In practical terms, it means that the two goods are close substitutes for each other in Syed's utility function. That is, the relative value a consumer places on two substitute goods will not change much depending on the amounts he has of one good versus the other. (It's no coincidence that this example features two goods that many consumers would consider to be close substitutes for each other.)

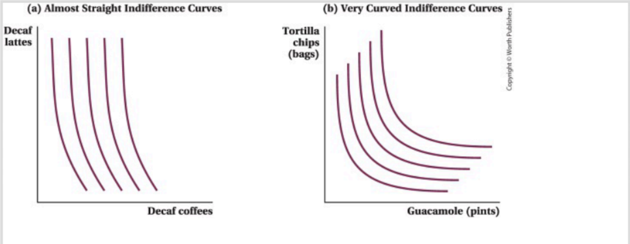

Figure 4.8 Curvature of Indifference Curves

The curvature of indifference curves reflects information about the consumer's preferences between two goods, just as its steepness does. (a) Goods that are highly substitutable (such as decaf lattes and decaf coffees) are likely to produce indifference curves that are relatively straight. This means the MRS does not change much as the consumer moves from one point to another along the indifference curve. (b) Goods that are complementary will generally have indifference curves with more curvature. For example, if a consumer has many tortilla chips and little guacamole, they will be willing to trade many tortilla chips to get some guacamole. If a consumer has a lot of guacamole and few tortilla chips, they will be less willing to trade chips for guacamole.

On the other hand, for goods such as tortilla chips and guacamole that are complements as in Figure 4.8b, the relative value of one more pint of guacamole will be much greater when you have a lot of chips and not much guacamole than if you have 10 pints of guacamole but no chips. In these types of cases, indifference curves are sharply curved, as shown. The MRS of guacamole for chips is very high on the far left part of the indifference curve (where the consumer does not have much guacamole) and very low on the far right (when the consumer is awash in guacamole). The intuition behind the meaning of the curvature of indifference curves may be easier to grasp if we focus on the most extreme cases: perfect substitutes and perfect complements.

Perfect Substitutes

Perfect substitutes are goods that a consumer can trade for another good, in fixed units, and receive the same level of utility. **Figure 4.9** offers an example of two goods that might be perfect substitutes: 12-ounce bags of tortilla chips and 3-ounce bags of tortilla chips. If all the consumer cares about is the total amount of chips, then that consumer is just as well off trading 4 small bags of chips for each large bag, regardless of how many of either they already have.[6] These kinds of preferences produce linear indifference curves, and utility functions for perfect substitutes take on the general form

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where a indicates the marginal utility of consuming one more unit of X and b indicates the marginal utility of consuming one more unit of Y. This is precisely the situation shown in Figure 4.9. Two goods that are perfect substitutes have indifference curves that are straight lines. In this case, the consumer is willing to trade one 12-ounce bag of tortilla chips for four 3-ounce bags of tortilla chips no matter how many of each they currently have, and the consumer's preference for chips does not change along the indifference curve. The MRS is constant in this case.

perfect substitute
A good that a consumer can trade for another good, in fixed units, and receive the same level of utility.

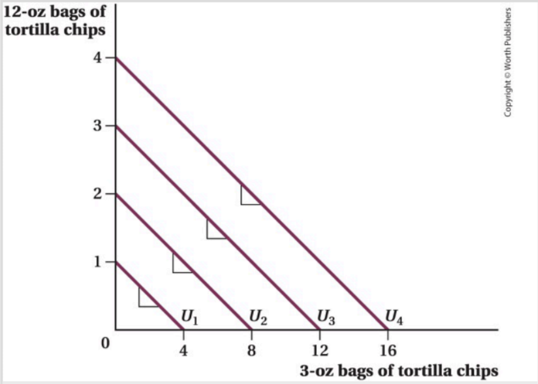

Figure 4.9 Indifference Curves for Perfect Substitutes

For perfect substitutes, the indifference curves are straight lines with a constant slope, in this case equal to
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which means that the
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is also constant and equal to 1/4. We can't actually say what values *a* and *b* take here, only that their ratio is 1 to 4—that is,
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The indifference curves in this example would be the same if
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and
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or if
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and
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for instance. This is another demonstration of the point we made above: A transformation of a utility function that does not change the order of which goods the consumer prefers implies the same preference choices.

Another form of perfect substitution might arise if a product has attributes that a consumer does not care about at all. For instance, it may not matter to some people if a bottle of water is branded Aquafina or Dasani. Their indifference curves when comparing Aquafina and Dasani water would therefore be straight lines. On the other hand, other consumers who *do* care about such features would not view the goods as perfect substitutes, and their indifference curves would be curved.

It is crucial to understand that two goods being perfect substitutes does *not* automatically imply that the consumer is indifferent between single items of the goods, one-for-one. In our tortilla chip example above, for instance, the consumer likes a big bag a lot more than a small bag. That's why they would have to receive 4 small bags, not just 1, to be willing to trade away 1 large bag. The idea behind perfect substitutes is only that the tradeoff the consumer is willing to make between the two goods—that is, the marginal rate of substitution—doesn't depend on how much or little they already have of each, but is instead constant at every point along an indifference curve.

Perfect Complements

Perfect complements are goods from which the consumer receives utility dependent on its being used in a fixed proportion with another good. **Figure 4.10** shows indifference curves for right and left shoes, which are an example of perfect complements (or at least something very close to it). Compare point *A* (2 right shoes and 2 left shoes) and point *B* (3 right shoes and 2 left shoes). Although the consumer has one extra shoe at point *B*, there is no matching shoe for the other foot, so the extra shoe is useless to them. The consumer is therefore indifferent between these two bundles, and the bundles are on the same indifference curve. Similarly, comparing points *A* and *C* in the figure, we see that an extra left-footed shoe provides no additional utility if it isn't paired with a right-footed shoe, so *A* and *C* must also lie on the same indifference curve. However, if you add an extra left shoe *and* an extra right shoe (point *D* compared to point *A*), then the consumer is better off. That's why *D* is on a higher indifference curve.

perfect complement
A good from which the consumer receives utility dependent on its being used in a fixed proportion with another good.

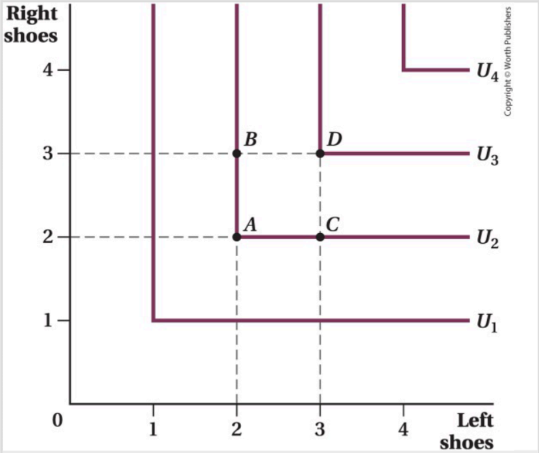

Figure 4.10 Indifference Curves for Perfect Complements

When goods are perfect complements, they have L-shaped indifference curves. For example, at point *A*, the consumer has 2 left shoes and 2 right shoes. Adding another right shoe while keeping the left shoes constant does not increase the consumer's utility, so point *B* is on the same indifference curve as point *A*. In like manner, adding another left shoe will not increase the consumer's utility without an additional right shoe, so point *C* is on the same indifference curve as points *A* and *B*. Because shoes are always consumed together, 1 right shoe and 1 left shoe, the consumer's utility rises only when they have more of both goods (a move from point *A* to point *D*).

Perfect complements lead to distinctive L-shaped indifference curves. Mathematically, this can be represented as

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where *a* and *b* are again numbers reflecting how consuming more units of *X* and *Y* affects utility. This mathematical structure means a consumer reaches a given utility level by consuming a minimum amount of each good *X* and *Y*. To be on the indifference curve

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for instance, the consumer must have *at least* 2 left shoes and 2 right shoes. The kink in the indifference curve is the point at which the consumer is consuming the minimum amount of each good at that utility level.[7]

This L-shape is the most extreme case of curvature of indifference curves. It is at the other extreme from the straight-line indifference curves that arise with perfect substitutes, and its shape produces interesting results for

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At the horizontal part of the indifference curve,

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equals zero, while on the vertical portion, the marginal rate of substitution is infinite. As we've noted, indifference curves more generally will fall somewhere in between the shapes of the indifference curves for perfect substitutes and perfect complements, with some intermediate amount of curvature.

Different Shapes for a Particular Consumer

One final point to make about the curvature of indifference curves is that even for a particular consumer, indifference curves may take on a variety of shapes depending on the utility level. They don't all have to look the same.

For instance, indifference curve

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in **Figure 4.11** is almost a straight line. This means that at low levels of utility, this consumer considers bananas and strawberries almost perfect substitutes. If all this consumer is worried about is getting enough calories to survive (which might be the case at really low utility levels like that represented by Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an they're not going to be picky about the mix of fruit they eat. Indifference curve Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an on the other hand, is very sharply curved. This means that at higher utility levels, the two goods are closer to perfect complements. When this consumer has plenty of fruit, they will likely prefer some of each fruit rather than a lot of one or the other. Remember, however, that even as the shapes of a consumer's indifference curves vary with their utility levels, the indifference curves will never intersect.

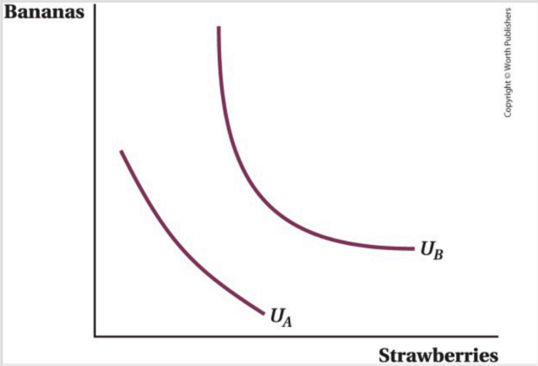

Figure 4.11 The Same Consumer Can Have Indifference Curves with Different Shapes

Indifference curves for a consumer can take on a variety of shapes, depending on the utility level. For example, at low levels of utility, bananas and strawberries may be substitutes and the consumer may just want to buy something for its calories, not caring whether it is a banana or strawberry. This means that the indifference curve will be close to linear, as is the case of Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml. But, at higher levels of utility, the consumer may prefer a variety of fruit. This means that they will be willing to give up many bananas for another strawberry when they have a lot of bananas, but are not willing to do so when they only have a few bananas. Here, the consumer's indifference curve will have more curvature, such as Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml.

figure it out 4.2

Ming can watch hours of videos on YouTube (*Y*) or hours of reality shows (*R*) on TV. Watching more YouTube makes Ming happier, but he really doesn't care about reality shows—good or bad. Draw a diagram showing a set of Ming's indifference curves for hours of YouTube and hours of reality shows. (Put reality shows on the horizontal axis.) What is Ming's Error parsing MathML: error on line 1 at column 933: Opening and ending tag mismatch: img line 0 and annotation-xml when he is consuming 1 unit of each good?

Solution:

The easiest way to diagram Ming's preferences is to consider various bundles of reality shows and YouTube, and determine whether they lie on the same or different indifference curves. For example, suppose he watches 1 hour of reality TV and 1 hour of YouTube. Plot this in Figure A as point *A*. Now suppose he watches 1 hour of reality TV and 2 hours of YouTube. Plot this as point *B*. Because watching more hours of YouTube makes Ming happier, point *B* must lie on a higher indifference curve than point *A*.

Next, try another point with 2 hours of reality TV and 1 hour of YouTube. Call this point *C*. Compare point *A* with point *C*. Point *C* has the same number of hours of YouTube as point *A*, but provides Ming with more reality TV. Ming neither likes nor dislikes reality TV, however, so his utility is unchanged by having more reality TV available. Points *A* and *C* must therefore lie on the same indifference curve. This would also be true of points *D* and *E*. Economists often refer to a good that has no impact on utility as a *neutral good*.

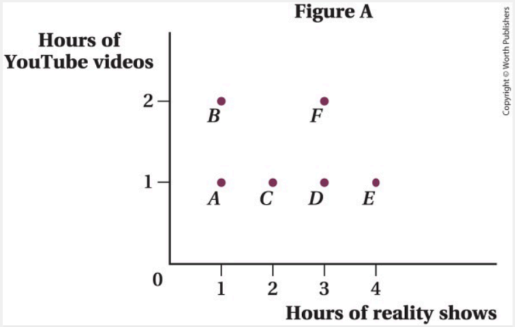
Figure A

Looking at Figure A, we see that there will be an indifference curve that is a horizontal line going through points *A*, *C*, *D*, and *E*. Will all the indifference curves be horizontal lines? Let's consider

another bundle to make sure. Suppose that Ming watches 3 hours of reality TV and 2 hours of YouTube, as at point *F*. It is clear that Ming will prefer point *F* to point *D* because he gets more YouTube. It should also be clear that Ming will be equally happy between points *B* and *F*; the same number of hours of YouTube are available to him, and reality shows have no effect on his utility. As shown in Figure B, points *B* and *F* lie on the same indifference curve
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and provide a greater level of utility than the bundles on the indifference curve below
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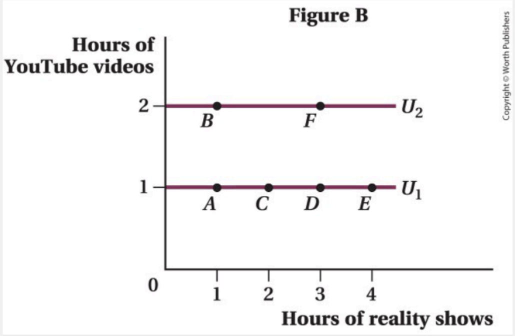

To calculate the marginal rate of substitution when Ming is consuming 1 unit of each good, we need to calculate the slope of
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at point *A*. Because the indifference curve is a horizontal line, the slope is zero. Therefore,
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is zero. This makes sense; Ming is not willing to give up any YouTube to watch more reality TV because reality TV has no impact on his utility. Remember that
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equals
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Because
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is zero,
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will also equal zero.

Application: Indifference Curves for “Bads”

Let’s look at some real-life data on house prices. Steven Levitt and Chad Syverson looked at how houses’ sale prices vary depending on their characteristics.[8] Their analysis, like Nevo’s work on breakfast cereals, uses hedonic regressions. Although the extent to which these types of analyses directly measure utility functions is controversial among economists, the details of that argument are not important to understanding our basic point here: Some products or services are the opposite of “goods.” Goods or services that provide a consumer with negative utility are called **bads**.

bad
A good or service that provides a consumer with negative utility.

Using regression techniques to compare otherwise similar houses (e.g., those having the same architectural style, the same type of siding material, and even located on the same city block), Levitt and Syverson found that an extra bedroom adds about 5% to the sale price of a house. Central air-conditioning adds about 7% to a house’s price, a “state-of-the-art kitchen” almost 8% more, and a fireplace brings in another 4%. The correlation between each of these amenities and the sale price of the house suggests that homebuyers are willing to pay for them. In other words, the number of bedrooms, central air, a state-of-the-art kitchen, and a fireplace are all “goods” (they just happen to be sold as pre-made bundles in the form of houses).

But Levitt and Syverson also uncovered a characteristic that had a negative effect on a house’s price, at least up to a point: its age. Again, comparing otherwise similar houses, they found that a house between 6–10 years old sold for 9% less than one that was built less than 6 years ago. Houses 11–25 years old, in turn, had sale prices that were 6% lower than those recorded for 6- to 10-year-old houses. There was another 3% drop in price for houses that were between 11–25 and 26–50 years old. (For houses older than that, prices stopped dropping and even rose slightly, suggesting that eventually, a home’s age may be regarded as a strong selling point.) Therefore, at least for houses less than 50 years old, age is a “bad”; all else equal, buyers receive lower utility from an older house than they would from an otherwise comparable but newer one.

The indifference curves for bundles of age (a bad) and bedrooms (a good) are shown in **Figure 4.12**. We see that the indifference curves slope upward, not downward. Why? Let’s first consider bundles *A* and *B*, which lie on the same indifference curve,
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A homebuyer who does not like old houses needs more bedrooms for the utility of bundle *B* (greater age, more bedrooms) to equal that of bundle *A* (younger age, fewer bedrooms). Bundle *C* has more space than bundle *A* but is the same age, so *C* must be preferred to *A*. Indifference curves that lie higher (more space) and to the left (not as old) indicate greater levels of utility.

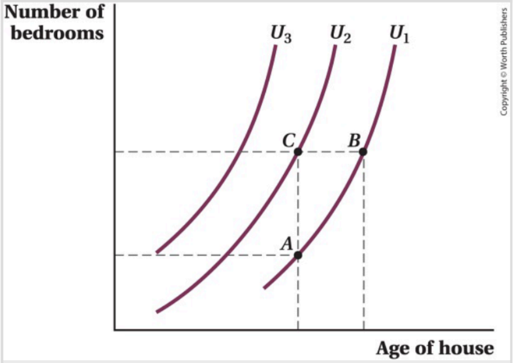

Figure 4.12 Indifference Curves for a "Bad"

An economic "bad" is a product that reduces a consumer's utility. This homebuyer's utility from a house falls as the age of the house increases. Therefore, to keep utility constant, we must provide the homebuyer with more bedrooms if we increase the house's age. This leads to upward-sloping indifference curves. Indifference curve
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provides more utility than
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because (holding the number of bedrooms constant) bundle *B* contains an older house than bundle *C*, making the homebuyer worse off. Alternatively, bundles *A* and *C* contain houses of the same age, but the house in bundle C has more bedrooms. Thus, the homebuyer is better off at point *C* (on
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than at point *A* (on
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml).

Although bads would seem to violate our assumption that more is better, we can always just redefine the age factor as "newness," or the *absence* of age. From this perspective, newness is a regular good, and our indifference curves for newness versus bedrooms then slope downward. Graphing our homebuyer's indifference curves in terms of how new a house is—the opposite of age—produces the standard, downward-sloping indifference curves we've been working with, as in **Figure 4.13**.

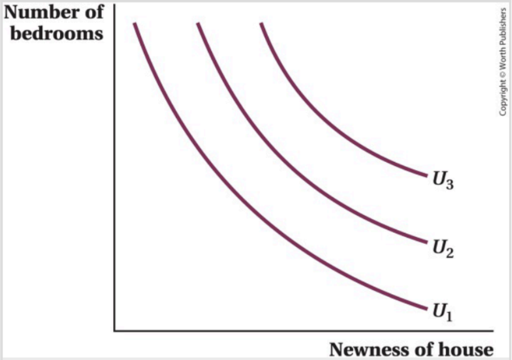

Figure 4.13 Indifference Curves for the Absence of a "Bad"

An economic "bad" can be converted into a "good." By changing the economic bad of a house's "increased age" into the economic good of a house's "newness," we can have two goods that our homeowner desires and produce typical downward-sloping, convex indifference curves. The homebuyer's utility increases with either an increase in the number of bedrooms in a house or an increase in the house's newness.

4.3 The Consumer’s Income and the Budget Constraint

In the preceding sections, we analyzed how a consumer’s preferences can be described by a utility function, why indifference curves are a convenient way to think about utility, and how the slope of the indifference curve—known as the marginal rate of substitution—captures the relative utility that a consumer derives from different goods at the margin. Our ultimate goal in this chapter is to understand how consumers maximize their utility by choosing a bundle of goods to consume. Because consumers have a limited amount of money and because goods are not free, consumers must make tradeoffs when deciding how much of each good to consume. The decision depends on not only the utility consumers get from each good, but also how much money they have to spend and the prices of the goods. We have to analyze the interaction among all these factors.

We must start with some assumptions (again, to keep things simple, we focus on a model with only two goods). We assume three things:

1. The consumer has a fixed amount of income available to spend. They cannot borrow or draw on savings. Without borrowing, the consumer can’t spend more than their income in any given period.
2. Each good has a fixed price (no discounts for buying in bulk, or buy-one-get-one-free deals!), and any consumer can buy as much of a good as they want at that price if they have the income to pay for it. We can make this assumption because each consumer is only a small part of the market for a good, so their individual consumption decision will not affect the equilibrium market price.
3. For now, the consumer cannot save any unspent income. With no saving, unspent money is lost forever—so it’s use it or lose it.

To incorporate prices and the consumer’s income into our model of consumer behavior, we use a **budget constraint**, a curve that describes the entire set of consumption bundles a consumer can purchase by spending all income. For instance, let’s go back to the example of Sarah and her burritos and lattes. Suppose Sarah has an income of $50 to spend on burritos (which cost $10 each) and lattes ($5 each). **Figure 4.14** shows the budget constraint corresponding to this example. The number of lattes is on the horizontal axis; the number of burritos is on the vertical axis. If Sarah spends her entire income on lattes, then she can consume 10 lattes (10 lattes at $5 each is $50) and no burritos. This combination is point *A* in the figure. If instead Sarah spends all her money on burritos, she can buy 5 burritos and no lattes, a combination shown at point *B*. Sarah can purchase any combination of burritos and lattes that lies on the straight line connecting these two points. For example, she could buy 3 burritos and 4 lattes. This is point *C*.

budget constraint
A curve that describes the entire set of consumption bundles a consumer can purchase when spending all income.

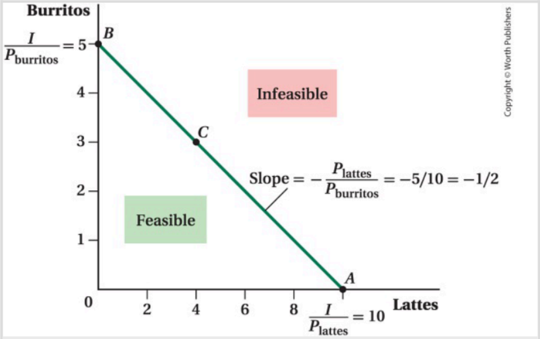

Figure 4.14 The Budget Constraint

The budget constraint demonstrates the options available to a consumer given their income and the prices of the two goods. Income is $50 in this example; the price of burritos is $10 and the price of lattes is $5. The horizontal intercept is the quantity of lattes the consumer could afford if they spent all of their income (*I*) on lattes,

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The vertical intercept is the quantity of burritos they could afford if they spent all of their income on burritos,

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Given this, the slope of the budget constraint is the negative of the ratio of the two prices,

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The mathematical formula for a budget constraint is

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where
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and
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are the prices for 1 unit of goods *X* and *Y* (lattes and burritos in our example), and
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and
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are the quantities of the two goods. The equation simply says that the total expenditure on the two goods (the per-unit price of each good multiplied by the number of units purchased) equals the consumer's total income.

Any combination of goods on or below the budget constraint that the consumer has the income to purchase (i.e., any point between the origin on the graph and the budget constraint, including those on the constraint itself) is a **feasible bundle**. Any combination of goods above or to the right of the budget line that the consumer cannot afford to purchase is an **infeasible bundle**. These bundles are beyond the consumer's reach even if they spend their entire income. Figure 4.14 illustrates the feasible and infeasible bundles for the budget constraint
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feasible bundle
Any combination of goods on or below the budget constraint that the consumer has the income to purchase.

infeasible bundle
Any combination of goods above or to the right of the budget line that the consumer cannot afford to purchase.

The budget constraint in Figure 4.14 is straight, not curved, because we assumed Sarah can buy as much as she wants of a good at a set price per unit. Whether buying the first latte or the tenth, we assume the price is the same. As we see later, if the goods' prices change with the number of units purchased, the budget line will change shape depending on the amount of the goods purchased. That's an unusual case, though.

The Slope of the Budget Constraint

The relative prices of the two goods determine the slope of the budget constraint. Because the consumer spends all their money when they are on the budget constraint line, if they want to buy more of one good and stay within their budget, they have to buy less of the other. Relative prices pin down the rate at which purchases of the two goods can be traded off. If they want to buy 1 more burrito (a cost of $10), for example, they'll have to buy 2 fewer lattes at $5.

We can see the equivalence between relative prices and the slope of the budget constraint by rearranging the budget constraint:

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The equation shows if
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—the quantity purchased of good *X*—increases by 1 unit, the quantity of good *Y*, or
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that can be bought falls by
Error parsing MathML: error on line 1 at column 959: Opening and ending tag mismatch: img line 0 and an
This ratio of the price of good *X* relative to the price of good *Y* is the negative of the slope of the budget constraint. It makes sense that this price ratio determines the slope of the constraint. If good *X* is expensive relative to good *Y* (i.e.,
Error parsing MathML: error on line 1 at column 959: Opening and ending tag mismatch: img line 0 and an
is large), then buying additional units of *X* will mean you must give up a lot of *Y* and the budget constraint line will be steep. If good *X* is relatively inexpensive, you don't have to give up a lot of *Y* to buy more *X*, and the constraint line will be flat.

We can use the equation for the budget constraint
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to find its slope and intercepts. Using the budget constraint

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shown in Figure 4.14, we get

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Dividing each side by 10—the price of

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—yields a slope of

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As we noted earlier, if Sarah spends all of her income on lattes, she will buy 10 lattes (the *x*-intercept), while she can purchase 5 burritos (the *y*-intercept) using all of her income. These relative prices and intercepts are illustrated in Figure 4.14.

As will become clear when we combine indifference curves and budget constraints in the next section, the slope of the budget constraint plays an important role in determining which consumption bundles maximize consumers' utility levels.

Factors That Affect the Budget Constraint

Because relative prices determine the slope of the budget constraint, changes in relative prices will change its slope. **Figure 4.15a** demonstrates what happens to our example budget constraint if the price of lattes doubles to $10. The budget constraint rotates clockwise around the vertical axis. Because

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doubles,

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doubles, and the budget constraint becomes twice as steep. If Sarah spends all her money on lattes, then the doubling of the price of lattes means she can buy only half as many lattes with the same income (the 5 lattes shown at

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rather than 10 lattes as before). If, on the other hand, she spends all her money on burritos (point *B*), then the change in the price of a latte doesn't affect the bundle she can consume. That's because the price of burritos is still the same ($10). Notice that after the price increase, the set of feasible consumption bundles is smaller: There are now fewer combinations of goods that Sarah can afford with her income.

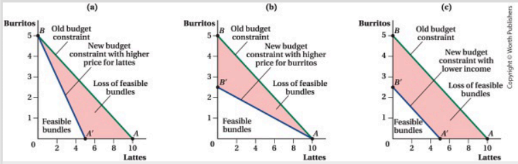

Figure 4.15 Effects of Price or Income Changes on the Budget Constraint

(a) When the price of lattes increases, the horizontal intercept

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falls, the slope

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gets steeper, the budget constraint rotates toward the origin, and the consumer (Sarah) has a smaller set of latte and burrito combinations from which to choose. The higher price for lattes means that she can buy fewer lattes, or if she purchases the same number of lattes, she has less money remaining to buy burritos.

(b) When the price of burritos increases, the vertical intercept

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falls, the slope

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gets flatter, the budget constraint rotates toward the origin, and again, Sarah has a smaller choice set. The higher price for burritos means that she can buy fewer burritos or, for a given purchase of burritos, she has less money available to buy lattes.

(c) When Sarah's income falls, both the horizontal and vertical intercepts fall and the budget constraint shifts in. The horizontal intercept is lower because income/falls;

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thus, falls. The same holds for the vertical axis. Because the movement along both axes is caused by the change in income (the reduction in *I* is the same along both axes), the new budget constraint is parallel to the initial budget constraint. Had both prices doubled while income stayed the same, the budget constraint would be the same.

If instead the price of a burrito doubles to $20, but that of a latte remains stable at the original $5 price (Figure 4.15b), the budget constraint's movement is reversed: It rotates counterclockwise around the horizontal axis, becoming half as steep. If Sarah wanted to buy only lattes, this wouldn't affect the number of lattes she could buy. If she wants only burritos, now she can obtain only half as many (if you could buy a half a burrito; we'll assume you can for now), at bundle *B*′. Notice that this price increase also shrinks the feasible set of bundles just as the lattes' price increase did. Always remember that when the price *rises,* the budget constraint rotates *toward* the origin. When the price *falls,* it rotates *away* from the origin.

Now suppose prices are stable but Sarah's income falls by half (to $25). With only half the income, Sarah can buy only half as many lattes and burritos as she could before (Figure 4.15c). If she spends everything on lattes, she can now buy only 5. If she buys only burritos, she can afford 2.5. But because relative prices haven't changed, the tradeoffs between the goods haven't changed. To buy 1 more burrito, Sarah still has to give up 2 lattes. Thus, the slope of the budget constraint remains the same.

Note that had both prices doubled while income stayed the same, the budget constraint would be identical to the new one shown in Figure 4.15c. We can see this more clearly if we plug in
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and
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for the prices in the slope-intercept format of the budget constraint:

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In both the figure and the equation, this type of change in prices decreases the purchasing power of the consumer's income, shifting the budget constraint inward. The same set of consumption bundles is feasible in either case. If Sarah's income had increased rather than decreased (or the prices of both goods had fallen in equal proportions), the budget constraint would have shifted out, not in. Its slope would remain the same, though, because the relative prices of burritos and lattes would not have changed.

We've now considered what happens to the budget constraint in two situations: when income changes while prices stay constant and when prices change, holding income constant. If prices and income both go up proportionally (e.g., all prices double and income doubles), then the budget constraint doesn't change at all. You have double the money but everything costs twice as much, so you can only afford the same bundles you could before. You can see this mathematically in the equation for the budget constraint above: If you multiply all prices and income by any positive number (call it *k*), all the *k*s will cancel out, leaving you with the original equation.

figure it out 4.3

Braden has $20 per week that he can spend on movie rentals (*R*), priced at $5 per game, and candy bars (*C*), priced at $1 each.

a. Write an equation for Braden's budget constraint and draw it on a graph that has movie rentals on the horizontal axis. Be sure to show both intercepts and the slope of the budget constraint.
b. Assuming he spends the entire $20, how many candy bars does Braden purchase if he chooses to rent 3 movies?
c. Suppose that the price of a movie rental falls from $5 to $4. Draw Braden's new budget line (indicating intercepts and the slope).

Solution:

a. The budget constraint represents the feasible combinations of movie rentals (*R*) and candy bars (*C*) that Braden can purchase given the current prices and his income. The general form of the budget constraint would be Error parsing MathML: error on line 1 at column 1202: Opening and ending tag mismatch: img line 0 and annotation-xml. Substituting in the actual prices and income, we get Error parsing MathML: error on line 1 at column 908: Opening and ending tag mismatch: img line 0 and annotation-xml.

To diagram the budget constraint, first find the horizontal and vertical intercepts. The horizontal intercept is the point on Braden's budget constraint where he spends all of his $20 on movie rentals. The *x*-intercept is at 4 rentals Error parsing MathML: error on line 1 at column 1102: Opening and ending tag mismatch: img line 0 and annotation-xml, point *A* on his budget constraint. The vertical intercept represents the point where Braden has used his entire budget to purchase candy bars. He could purchase 20 candy bars Error parsing MathML: error on line 1 at column 1102: Opening and ending tag mismatch: img line 0 and annotation-xml as shown at point *B*. Because the prices of candy bars and movie rentals are the same no matter how many Braden buys, the budget constraint is a straight line that connects these two points.

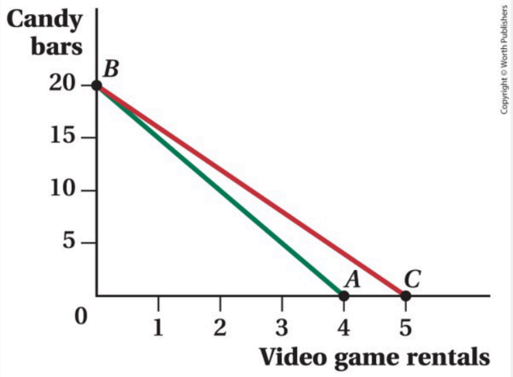
The slope of the budget constraint can be measured by the rise over the run. Therefore, it is equal to Error parsing MathML: error on line 1 at column 2199: Opening and ending tag mismatch: img line 0 and annotation-xml.

We can check our work by recalling that the slope of the budget constraint is equal to the negative of the ratio of the two prices or Error parsing MathML: error on line 1 at column 2196: Opening and ending tag mismatch: img line 0 and annotation-xml. Remember that the slope of the budget constraint shows the rate at which Braden is able to exchange candy bars for movie rentals.

b. If Braden currently purchases 3 movie rentals, that means he spends Error parsing MathML: error on line 1 at column 1341: Opening and ending tag mismatch: img line 0 and annotation-xml on them. This leaves Error parsing MathML: error on line 1 at column 1721: Opening and ending tag mismatch: img line 0 and annotation-xml for purchasing candy bars. At a price of $1 each, Braden purchases 5 candy bars.

c. When the price of a movie rental falls to $4, the vertical intercept is unaffected. If Braden chooses to spend his $20 on candy bars, at a price of $1, he can still afford to buy 20 of them. Thus, point *B* will also be on his new budget constraint. However, the horizontal intercept increases from 4 to 5. At a price of $4 per rental, Braden can now afford 5 rentals if he chooses to allocate his entire budget to rentals (point *C*). His new budget constraint joins points *B* and *C*.

The slope of the budget constraint is Error parsing MathML: error on line 1 at column 2188: Opening and ending tag mismatch: img line 0 and annotation-xml. Note that this equals the inverse price ratio of the two goods Error parsing MathML: error on line 1 at column 2455: Opening and ending tag mismatch: img line 0 and annotation-xml.



Nonstandard Budget Constraints

In all the examples so far, the budget constraint has been a straight line. There are some cases in which the budget constraint would be kinked instead.

Quantity Discounts

Suppose Alex spends his $100 weekly income on pizzas and data usage on his phone. A pizza costs $10; if he spends everything on pizzas, he can buy 10. If the price of phone data is constant at 10 cents per MB, he can buy up to 1 GB (1,000 MBs) of data (Figure 4.16). The budget constraint in the case where data use costs a constant 10 cents per MB is given by the solid section of the line running from zero MBs and 10 pizzas up to 1,000 MBs and zero pizzas.

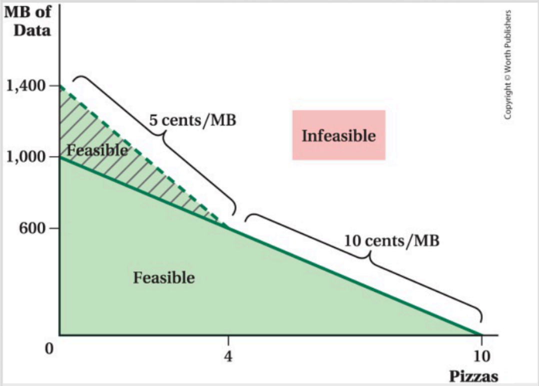


Figure 4.16 Quantity Discounts and the Budget Constraint

When the price of phone data is constant at 10 cents per MB, Alex's budget constraint for megabytes of data and pizza has a constant slope, as represented by the solid line. If the phone company offers a quantity discount on data, however, Alex's budget constraint will be kinked. Here, Alex's data plan charges 10 cents per MB for the first 600 MBs per month and 5 cents per MB after that, resulting in the kink at 600 MBs shown by the dashed line. The triangle above the initial budget constraint and below the dashed line represents the set of MBs of data and pizza combinations Alex can afford under the new pricing scheme that he could not have purchased at a constant price of 10 cents per MB.

Phone plans often offer quantity discounts on data. With a quantity discount, the price the consumer pays per unit of the good depends on the number of units purchased. If Alex's calling plan charges 10 cents per MB for the first 600 MBs per month and 5 cents per MB after that, his budget constraint will have a kink. In particular, because data usage gets cheaper above 600 MBs, the actual budget constraint has a kink at 600 MBs and 4 pizzas. Because the price of the good on the *y*-axis (data usage) becomes relatively cheaper, the constraint rotates clockwise at that quantity, becoming steeper. To find where the budget constraint intercepts the vertical axis, we have to figure out how many MBs Alex can buy if he purchases only data. This total is 1,400 MBs

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In Figure 4.16, the resulting budget constraint runs from 10 pizzas and zero MBs to 4 pizzas and 600 MBs (part of the solid line) and then continues up to zero pizzas and 1,400 MBs (the dashed line).

Quantity Limits

Another way a budget constraint can be kinked is if there is a limit on how much of one good can be consumed. When the newest iPhone model comes out, Apple often sets a limit of one per customer. Similarly, during World War II in the United States, certain goods like sugar and butter were rationed. Each family could buy only a limited quantity. And during the Covid pandemic, some stores limited the amount of toilet paper people could buy. These limits have the effect of creating a kinked budget constraint.[9]

Suppose that Alex's carrier or the government (or maybe his parents) expressly capped Alex's weekly data usage at 600 MBs per week. In that case, the part of the budget constraint beyond 600 MB becomes infeasible, and the constraint becomes horizontal at 600, as shown by the solid line in **Figure 4.17**. Note that neither Alex's income nor any prices have changed in this example. He still has enough money to reach any part in the area below the dashed section of the budget constraint that is labeled infeasible. He just isn't allowed to spend it. Consequently, for the flat part of the budget constraint, he will have unspent money left over. As we see in the next section, you will never actually want to consume a bundle on the flat part of the budget constraint. (You might want to see if you can figure out why yourself, before we tell you the answer.)

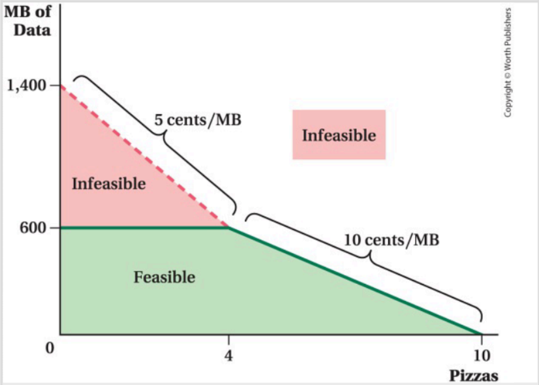

Figure 4.17 Quantity Limits and the Budget Constraint

When there is a limit on how much of a good a person can consume, a budget constraint will be kinked. When Alex is limited to 600 MBs of data per week, his budget constraint is horizontal at that quantity. The triangle above the horizontal section of the budget constraint and below the dashed line represents the set of data and pizzas that are now infeasible for Alex to buy. Note that Alex can still afford these sets since his income and the prices have not changed, but the restrictions on how much he can purchase dictate that he cannot buy them.

FREAKONOMICS

Do Traffic Jams Lead to Divorce?

There are lots of reasons why couples get divorced. Traffic jams are not typically something we expect to be at the top of that list. In Beijing, however, bad traffic is leading to divorces, but you would never guess the reason why.

Beijing has some of the worst traffic in the world. As the Chinese economy grew, so did the demand for automobiles. The resulting traffic jams and air pollution became so severe that government officials formed a committee to find a solution to traffic congestion. It came up with a plan many considered excellent: The city would limit the number of new license plates issued each month. Without an official license plate, you could not drive a car, so this policy would bring a halt to the mounting number of automobiles. It was further decided that, to give all of Beijing's residents a fair chance, the license plates would be awarded by lottery, held on the 26th of each month.

The policy had an effect—but it was definitely not the one government officials had hoped for, and for reasons any economist could have predicted. It dramatically reduced the supply of new license plates and kept the price of a new plate low should you happen to win the lottery. The number of consumers who wanted a license plate at that reduced price was far greater than the number available, making the chance of winning the lottery low. Knowing that, people who didn't even own a car at that point entered the lottery anyway. If they were lucky enough to win, they could hold onto their new plates until ready to actually purchase a car. The likelihood of winning the lottery was so low—1 in 1,907—that not many people had to worry about winning a license plate before they were able to use it!

When government policies prevent a market from reaching equilibrium, consumers find ways to get around the policy. A black market in license plates soon sprung up. Another solution was for Beijing residents to buy a car in another province and then just transport it to the city (even though that action was illegal, and the police could fine you 100 to 200 RMB, or $15 to $30, each time they stopped you).

There is only one legal way to transfer a license plate from one person to another in Beijing: through marriage. If, say, a wife wins the lottery, she is allowed to give that license plate to her husband. How badly did some people want license plates? Well, it turns out some happily married couples decided to get a divorce. One of the partners would then pay a lottery winner to marry him (or her), transfer the license plate, immediately seek a divorce, and then remarry the original spouse!

This is how bad traffic—combined with government policies that do not respect the power of supply and demand—could lead someone to get divorced not just once, but twice.

VCG/Getty Images

4.4 Combining Utility, Income, and Prices: What Will the Consumer Consume?

We now have in place all the pieces necessary to figure out what a consumer will buy. We know the consumer’s preferences for bundles of goods from the utility function and its associated indifference curves. We know the consumer’s budget constraint and which bundles are feasible given their income and the goods’ prices.

Solving the Consumer’s Optimization Problem

As we mentioned in the introduction to this chapter, the choice of how much to consume (like so many economic decisions) is a *constrained optimization* problem. There is something you want to maximize (utility, in this case), and there is something that limits how much you can get (the budget constraint, in this case). And as we will see in the next chapter, the constrained optimization problem forms the basis of the demand curve.

Before we try to solve this constrained optimization problem, think about what makes it tricky: We must compare some things measured in dollars (like income and prices) to other things measured in imaginary units that don’t translate into dollars (like utils of utility). How can you know whether you’re willing to pay $3 to get an extra unit of utility? Well, you can’t, really. What you can figure out, however, is whether spending an extra dollar on, say, golf balls gives you more or less utility than spending an extra dollar on something else, like AAA batteries. It turns out that figuring out this choice using indifference curves and budget constraints makes solving the consumer’s optimization problem straightforward.

Look at the axes we use to show indifference curves and budget constraints. They are the same: The quantity of some good is on the vertical axis, and the quantity of some other good is on the horizontal axis. That’s important because it means we can display indifference curves and the budget constraint for two goods in the same graph, making the consumer’s problem easier to solve.

Figure 4.18 presents an example that shows a combination of indifference curves and a budget constraint. Remember, the consumer wants to get as much utility as possible from consuming the two goods, subject to the limits imposed by their budget constraint. What bundle will they choose? The bundle at point *A*. That’s the highest indifference curve they can reach given their budget line.

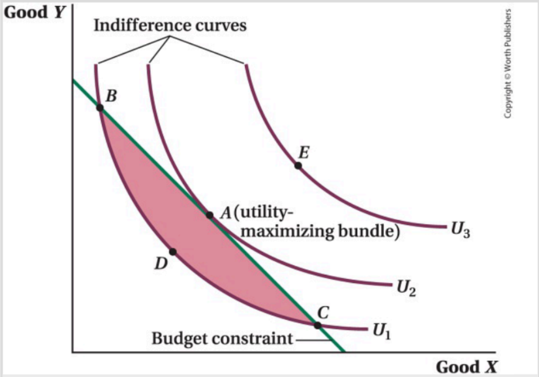

Figure 4.18 The Consumer’s Optimal Choice

The consumer’s optimal consumption bundle occurs at the point of tangency between their budget constraint and their indifference curve, shown here at point *A*. The consumer can afford the consumption bundles represented by points *B*, *C*, and *D*, but these are on a lower indifference curve

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than is point

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Point *E* is on a higher indifference curve

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but it lies outside the consumer’s budget constraint and is thus infeasible.

Why is *A* the utility-maximizing consumption bundle? Compare point *A* to another feasible bundle, such as *B*. Point *B* is on the budget constraint, so the consumer could afford it. However, because *B* is on a lower indifference curve

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than *A* is

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bundle *B* provides less utility than *A*. Bundles *C* and *D*, too, are feasible but worse than *A* in terms of utility provided because they are on the same indifference curve as *B*. The consumer would love to consume bundle *E* because it's on an indifference curve

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that corresponds to a higher utility level than

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Unfortunately, the consumer can't afford *E*. It's outside their budget constraint. Basically, the consumer reaches for the sky but can only get as high as the budget constraint will allow.

A look at the consumer's optimal consumption bundle *A* in Figure 4.18 shows that it has a special feature: The indifference curve,

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touches the budget constraint once and only once, exactly at *A*. Mathematically speaking,

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and the budget constraint are tangent at point *A*. As long as the original assumptions we made about utility hold, no other indifference curve we can draw will have this feature. Any other indifference curve will not be tangent, and therefore will cross the budget constraint twice or not at all. If you can draw another indifference curve that is tangent, it will cross an indifference curve shown in Figure 4.18, violating the transitivity assumption. (Give it a try—it is a useful exercise.)

This single tangency is not a coincidence. It is a requirement of utility maximization. To see why, suppose an indifference curve and the budget constraint never touched. Then no point on the indifference curve is feasible, and by definition, no bundle on that indifference curve can be the way for a consumer to maximize their utility given their income.

Then suppose the indifference curve crosses the budget constraint twice. This implies there must be a bundle that offers the consumer higher utility than any on this indifference curve and that the consumer can afford. For example, the shaded region between indifference curve

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and the budget constraint in Figure 4.18 reflects all the bundles that are feasible and provide higher utility than bundles *B*, *C*, *D*, or any other point on

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That means no bundle on

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maximizes utility; there are other bundles that are both affordable *and* offer higher utility. This means that only at a point of tangency are there no other bundles that are both (1) feasible and (2) offer a higher utility level. This tangency is the utility-maximizing bundle for the consumer.

Mathematically, the tangency of the indifference curve and budget constraint means that they have the same slope at the optimal consumption bundle. This has an important economic interpretation. In Section 4.2, we defined the negative of the slope of the indifference curve as the marginal rate of substitution, and we discussed how the

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reflects the ratio of the *marginal utilities* of the two goods. In Section 4.3, we saw that the slope of the budget constraint equals the negative of the ratio of the *prices* of the two goods. Therefore, the fact that the consumer's utility-maximizing bundle is at a tangency between an indifference curve and the budget constraint gives us this key insight: *When an individual consumer spends all their income and maximizes their utility, their optimal consumption bundle is the one at which the ratio of the goods' marginal utilities exactly equals the ratio of the goods' prices.*

This economic idea behind utility maximization can be expressed mathematically. At the point of tangency,

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Why are the marginal utility and price ratios equal when the consumer maximizes their utility level? If they were not equal, the consumer could do better by shifting consumption from one good to the other. To see why, let's say Meredith is maximizing her utility over bottles of Gatorade and protein bars. Suppose bottles of Gatorade are twice as expensive as protein bars, but she is considering a bundle in which her marginal utilities from the two goods *are not* 2 to 1 as the price ratio is. Say she gets the same amount of utility at the margin from another bottle of Gatorade as from another protein bar so that the ratio of the goods' marginal utilities is 1. Given the relative prices, she could give up 1 bottle of Gatorade and buy 2 more protein bars, and doing so would let her reach a higher utility level. Those 2 extra protein bars are worth twice as much in utility terms as the lost bottle of Gatorade.

Now suppose that a bottle of Gatorade offers Meredith 4 times the utility at the margin as a protein bar. The ratio of Meredith's marginal utilities for Gatorade and protein bars (4 to 1) is higher than the price ratio (2 to 1), so she could buy 2 fewer protein bars in exchange for 1 more bottle of Gatorade. Because the Gatorade delivers twice the utility lost from the 2 protein bars, Meredith will be better off buying fewer protein bars and more Gatorade.

It is often helpful to rewrite this optimization condition in terms of the consumer's marginal utility per dollar spent:

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Appendix 4A, located at the end of this chapter, uses calculus to solve the consumer's utility-maximization problem.

Here, the utility-maximization problem can be restated as finding the consumption bundle that gives the consumer the most bang for their buck. This occurs when the marginal utility per dollar spent

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is equal across all goods. If this is not the case, the consumer can improve their utility by adjusting their consumption of good *X* and good *Y*.[10]

figure it out 4.4

Suppose Antonio gets utility from consuming two goods, burgers and fries. His utility function is given by

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where *B* is the number of burgers he eats and *F* the servings of fries. Antonio's marginal utility of a burger
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and his marginal utility of an order of fries
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Antonio's income is $20, and the prices of burgers and fries are $5 and $2, respectively. What are Antonio's utility-maximizing quantities of burgers and fries?

Solution:

We know that the optimal solution to the consumer's maximization problem sets the marginal rate of substitution—the ratio of the goods' marginal utilities—equal to the goods' price ratio:

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where
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and
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are the goods' prices. Therefore, to find the utility-maximizing quantities of burgers and fries, we set the ratio of marginal utilities equal to the goods' price ratio and simplify:

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This condition tells us that Antonio maximizes his utility when he consumes fries to burgers at a 5 to 2 ratio. We now know the ratio of the optimal quantities, but do not yet know exactly what quantities Antonio will choose to consume. To figure that out, we can use the budget constraint, which pins down the total amount Antonio can spend, and therefore the total quantities of each good he can consume.

Antonio's budget constraint can be written as

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Substituting in the values from the problem gives

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Now we can substitute the utility-maximization condition Error parsing MathML: error on line 1 at column 746: Opening and ending tag mismatch: img line 0 and annotation-xml into the budget constraint to find the quantity of burgers Antonio will consume:

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And because Error parsing MathML: error on line 1 at column 746: Opening and ending tag mismatch: img line 0 and annotation-xml, then Error parsing MathML: error on line 1 at column 687: Opening and ending tag mismatch: img line 0 and annotation-xml.

Therefore, given his budget constraint, Antonio maximizes his utility by consuming 2 burgers and 5 servings of fries.

Implications of Utility Maximization

The marginal-utility-ratio-equals-price-ratio result has another implication for the economy as a whole that can initially be surprising. Even if two consumers have very different preferences between two goods, they will have the *same* ratio of marginal utilities for the two goods in equilibrium, because utility maximization implies that the MRS for each of them will equal the ratio of the prices, and that ratio is the same for both of them.[11]

This might seem odd. First of all, we have said that you can't compare utility levels across people. Second, even if you could—if, say, Jack consumes 9 packs of gum and 1 iTunes download, while Meg consumes 9 downloads and only 1 pack of gum—it would seem that Jack likes gum a lot and would therefore be willing to pay more for another pack of gum (and a lot less for iTunes) than Meg.

That would be true *if both Jack and Meg had to consume the same bundle,* but they don't. They can choose how much of each good they want to consume. Because Jack likes gum a lot, he will consume so much of it that he drives down his marginal utility until, by the time he and Meg both reach their utility-maximizing consumption bundles, they will both end up placing the same relative marginal utilities on the two goods. This outcome occurs because the relative value they place on any two goods (on the margin) comes from the relative prices. Because Meg and Jack face the same prices, the goods they consume will end up with the same relative marginal utilities.

Figure 4.19 depicts this very situation. To keep the picture simple, let Jack and Meg have the same incomes. Because they also face the same relative prices, their budget constraints are the same. Jack really likes gum relative to iTunes downloads, so his indifference curve tends to be flat: He has to be given a lot of iTunes to make up for any loss of gum. Meg feels the opposite. She has to receive quite a bit of gum to make up for relinquishing an iTunes download, so her indifference curve is steep. Nevertheless, both Jack and Meg's utility-maximizing bundles are on the same budget line, and they will pick consumption points where their marginal rates of substitution at those bundles are the same (and match the relative prices). We've drawn the indifference curves for Jack

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and Meg

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so that they are tangent to the budget line and therefore contain the utility-maximizing bundle.

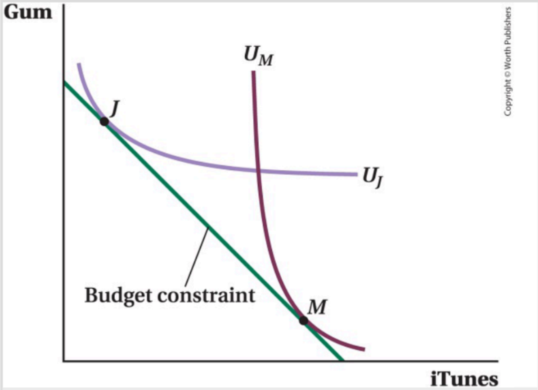

Figure 4.19 Two Consumers' Optimal Choices

Although they have the same budget constraint, Jack and Meg have different relative preferences and, therefore, different optimal consumption bundles. Because Jack likes gum relative to iTunes downloads, his indifference curve
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is flat and he consumes much more gum than iTunes at his optimal consumption bundle at point *J*. Meg's indifference curve
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is much steeper and reflects her relative preference for iTunes downloads over gum; her utility-maximizing bundle is shown at point *M*. Although their consumption bundles are different, the MRS is the same at these points.

Even though Jack and Meg have the same
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the amounts of each good they consume are different. Jack, the gum lover, maximizes his utility by choosing a bundle (*J*) with a lot of gum and not many iTunes downloads. Meg's optimal consumption bundle (*M*), on the other hand, has a lot of iTunes downloads and little gum. Again, both consumers end up with the same MRS in their utility-maximizing bundles because each consumes a large amount of the good for which they have the stronger preference. By behaving in this way, Jack and Meg drive down the relative marginal utility of the good they prefer until their marginal utility ratio equals the price ratio.

Note that these two indifference curves cross. Although earlier we learned that indifference curves can never cross, the "no crossing" rule applies only to the indifference curves of one individual. Figure 4.19 shows indifference curves for two different people with different preferences, so the *transitivity* rule we talked about before doesn't hold. If you like gum more than iTunes, and your friend likes iTunes more than, say, coffee, that doesn't imply you have to like gum more than coffee. So, the same consumption bundle (say, 3 packs of gum and 5 iTunes downloads) can offer different utility levels to different people.

A Special Case: Corner Solutions

Up to this point, we have analyzed situations in which the consumer optimally consumes some of both goods. This assumption usually makes sense if we think that utility functions have the property that the more you have of a good, the less you are willing to give up of something else to get more. Because the first little bit of a good provides the most marginal utility in this situation, a consumer will typically want at least *some* amount of a good.

Depending on the consumer's preferences and relative prices, however, in some cases a consumer will not want to spend any of their money on a good. A utility-maximizing bundle located at the "corner" of the budget constraint where the consumer purchases only one of two goods is called a **corner solution**. (Its name derives from the fact that the optimal consumption bundle is at the "corner" of the budget line, where it meets the axis.) A utility-maximizing bundle that contains positive quantities of both goods (like the cases we've looked at so far in this chapter) is called an **interior solution**.

corner solution
A utility-maximizing bundle located at the "corner" of the budget constraint where the consumer purchases only one of two goods.

interior solution
A utility-maximizing bundle that contains positive quantities of both goods.

Figure 4.20 depicts a corner solution. Greg, our consumer, has an income of $240 and is choosing his consumption levels of mystery novels and Bluetooth speakers. Let's say a hardcover mystery novel costs $20, and a Bluetooth speaker costs $120. Because speakers are more expensive than mystery novels, Greg can afford up to 12 mysteries but only 2 speakers. Nonetheless, the highest utility that Greg can obtain given his income is bundle *A*, where he consumes all speakers and no mystery novels.

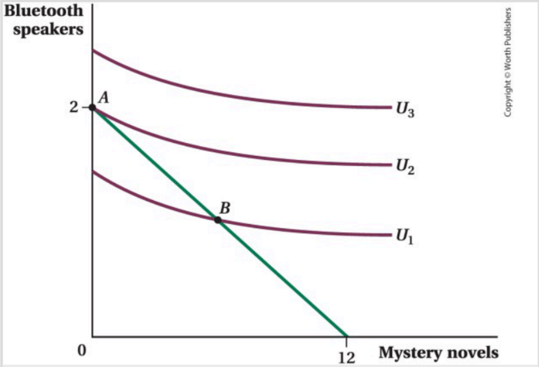

Figure 4.20 A Corner Solution

A corner solution occurs when the consumer spends all his money on one good. Given Greg's income and the relative prices of mystery novels and Bluetooth speakers, Greg is going to consume two speakers and zero mystery novels at his optimal consumption bundle (*A*). All other feasible consumption bundles, such as point *B*, correspond to indifference curves with lower utility levels than the indifference curve

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at the point *A*. Greg cannot afford consumption bundles at a higher utility level, such as

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with his current income.

How do we know *A* is the optimal bundle? Consider another feasible bundle, such as *B*. Greg can afford it, but it is on an indifference curve

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that corresponds to a lower utility level than

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The same logic would apply to bundles on any indifference curve between

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and

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Furthermore, any bundle that offers higher utility than

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(i.e., above and to the right of

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isn't feasible given Greg's income. So,

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must be the highest utility level Greg can achieve, and he can do so only by consuming bundle *A*, because that's the only bundle he can afford on that indifference curve.

Appendix 4B further explains the mathematics of corner solutions.

In a corner solution, then, the highest indifference curve touches the budget constraint exactly once, just as with the interior solutions we discussed earlier. The only difference with a corner solution is that bundle *A* is not a point of tangency. The indifference curve is flatter than the budget constraint at that point (and everywhere else). That means Greg's MRS—the ratio of his marginal utility from mystery novels relative to his marginal utility from Bluetooth speakers—is *less* than the price ratio of the two goods rather than equal to it. In other words, even when he's consuming no mysteries, his marginal utility from them is so low, it's not worth paying the price of a book to be able to consume one. The marginal utility he'd have to give up with fewer speakers would not be made up for by the fact that he could spend some of his money on novels.

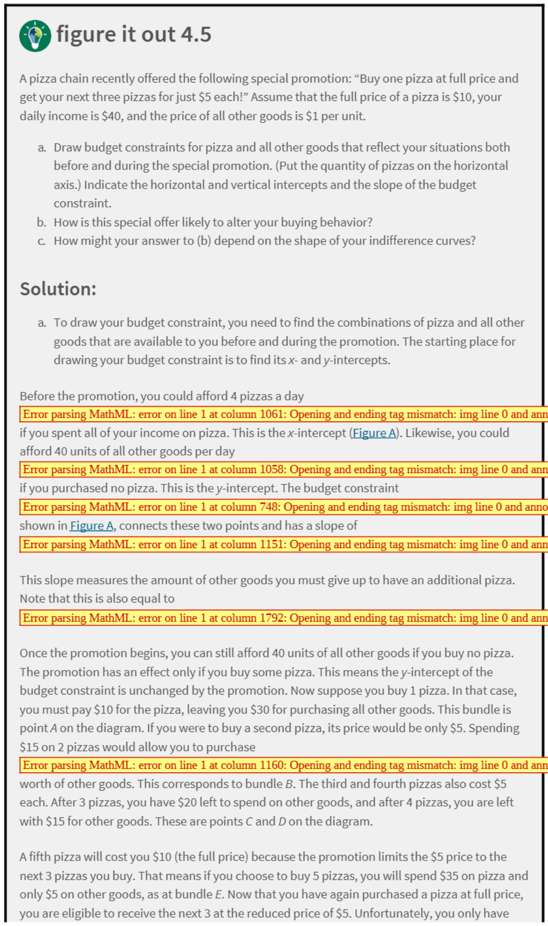

figure it out 4.5

A pizza chain recently offered the following special promotion: "Buy one pizza at full price and get your next three pizzas for just $5 each!" Assume that the full price of a pizza is $10, your daily income is $40, and the price of all other goods is $1 per unit.

a. Draw budget constraints for pizza and all other goods that reflect your situations both before and during the special promotion. (Put the quantity of pizzas on the horizontal axis.) Indicate the horizontal and vertical intercepts and the slope of the budget constraint.
b. How is this special offer likely to alter your buying behavior?
c. How might your answer to (b) depend on the shape of your indifference curves?

Solution:

a. To draw your budget constraint, you need to find the combinations of pizza and all other goods that are available to you before and during the promotion. The starting place for drawing your budget constraint is to find its *x*- and *y*-intercepts.

Before the promotion, you could afford 4 pizzas a day
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if you spent all of your income on pizza. This is the *x*-intercept (Figure A). Likewise, you could afford 40 units of all other goods per day
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if you purchased no pizza. This is the *y*-intercept. The budget constraint
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shown in Figure A, connects these two points and has a slope of
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This slope measures the amount of other goods you must give up to have an additional pizza. Note that this is also equal to
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Once the promotion begins, you can still afford 40 units of all other goods if you buy no pizza. The promotion has an effect only if you buy some pizza. This means the *y*-intercept of the budget constraint is unchanged by the promotion. Now suppose you buy 1 pizza. In that case, you must pay $10 for the pizza, leaving you $30 for purchasing all other goods. This bundle is point *A* on the diagram. If you were to buy a second pizza, its price would be only $5. Spending $15 on 2 pizzas would allow you to purchase
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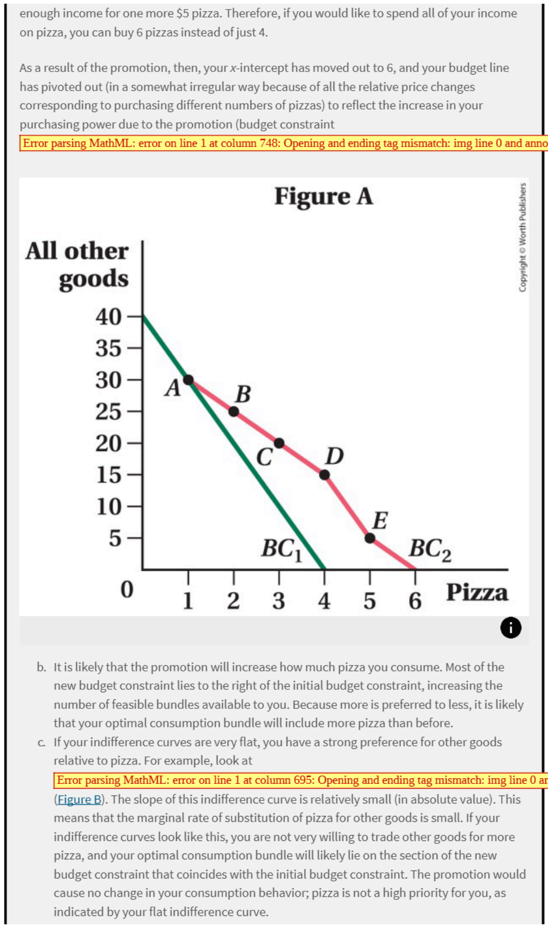
worth of other goods. This corresponds to bundle *B*. The third and fourth pizzas also cost $5 each. After 3 pizzas, you have $20 left to spend on other goods, and after 4 pizzas, you are left with $15 for other goods. These are points *C* and *D* on the diagram.

A fifth pizza will cost you $10 (the full price) because the promotion limits the $5 price to the next 3 pizzas you buy. That means if you choose to buy 5 pizzas, you will spend $35 on pizza and only $5 on other goods, as at bundle *E*. Now that you have again purchased a pizza at full price, you are eligible to receive the next 3 at the reduced price of $5. Unfortunately, you only have



enough income for one more $5 pizza. Therefore, if you would like to spend all of your income on pizza, you can buy 6 pizzas instead of just 4.

As a result of the promotion, then, your *x*-intercept has moved out to 6, and your budget line has pivoted out (in a somewhat irregular way because of all the relative price changes corresponding to purchasing different numbers of pizzas) to reflect the increase in your purchasing power due to the promotion (budget constraint
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Figure A

b. It is likely that the promotion will increase how much pizza you consume. Most of the new budget constraint lies to the right of the initial budget constraint, increasing the number of feasible bundles available to you. Because more is preferred to less, it is likely that your optimal consumption bundle will include more pizza than before.
c. If your indifference curves are very flat, you have a strong preference for other goods relative to pizza. For example, look at
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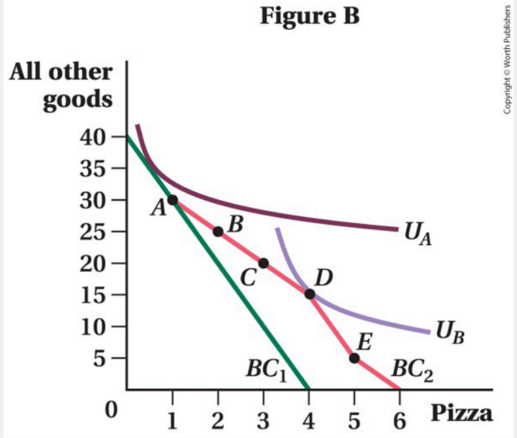
(Figure B). The slope of this indifference curve is relatively small (in absolute value). This means that the marginal rate of substitution of pizza for other goods is small. If your indifference curves look like this, you are not very willing to trade other goods for more pizza, and your optimal consumption bundle will likely lie on the section of the new budget constraint that coincides with the initial budget constraint. The promotion would cause no change in your consumption behavior; pizza is not a high priority for you, as indicated by your flat indifference curve.



On the other hand, if your indifference curves are steeper, like Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml, your marginal rate of substitution is relatively large, indicating that you are willing to forgo a large amount of other goods to consume an additional pizza. Then this promotion will, more than likely, cause you to purchase additional pizzas.

4.5 Conclusion

In this chapter, we looked at how consumers decide what to consume. This decision combines two characteristics of consumers, their preferences (embodied in their utility functions) and their income, and one characteristic of the market, the goods' prices.

We saw that a consumer maximizes their utility from consumption when they choose a bundle of goods such that the marginal rate of substitution between the goods equals their relative prices. That is, in this bundle the ratio of the goods' marginal utilities equals their price ratio. Equivalently, the goods' marginal utilities per dollar spent are equal. If this property didn't hold, a consumer could make themself better off by consuming more of the good with the high marginal utility per dollar and less of the good with the low marginal utility per dollar.

Summary

1. **Utility** is the economic concept of consumers' happiness or well-being, and the **utility function** is the construct that relates the amount of goods consumed (the inputs) to the consumer's utility level (the output). There are properties that we expect almost all utility functions to share: the completeness, rankability, and transitivity of utility bundles; that having more of a good is better than having less; and that the more an individual consumer has of a particular good, the less willing they are to give up something else to get more of that good. **[**Section 4.1**]**
2. Consumers' preferences are reflected in their **indifference curves,** which show all the combinations of goods over which a consumer receives equal utility. The set of properties imposed on utility functions imply some restrictions on the shapes of indifference curves. Namely, indifference curves slope downward, never cross for a given individual, and are convex to the origin. **[**Section 4.2**]**
3. The negative of the slope of the indifference curve is the **marginal rate of substitution of good *X* for good *Y***

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   It reflects how much of one good a consumer would need to give up in order to have an additional unit of another good. The MRS is the ratio of the marginal utilities of the goods in the utility function. **[**Section 4.2**]**
4. Consumer preferences lead to differences in the steepness and curvature of indifference curves. If a consumer views two goods as **perfect substitutes** or **perfect complements,** their indifference curves will be shaped like straight lines and right angles, respectively. **[**Section 4.2**]**
5. The consumer's decision about how much of each good to consume depends on not only utility, but also how much money that person has to spend (their income) and the prices of the goods. In analyzing the role of income in consumption decisions, we assume the following: Each good has a fixed price, and any consumer can buy as much of a good as they want at that price if the consumer has sufficient income to pay for it; the consumer has some fixed amount of income to spend; and the consumer cannot save or borrow.

   The **budget constraint** captures both a consumer's income and the relative prices of goods. The constraint shows which **consumption bundles** are **feasible** (i.e., affordable given the consumer's income) and which are **infeasible.** The slope of the budget constraint is the negative of the ratio of the prices of the two goods

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   Section 4.3**]**
6. The consumer's decision is a constrained optimization problem: to maximize utility while staying within their individual budget constraint. The utility-maximizing solution is generally to consume the bundle of goods located where an indifference curve is tangent to the budget constraint. At this optimal point, the consumer's marginal rate of substitution—the ratio of the consumer's marginal utilities from the goods—equals the goods' relative price ratio.

   A **corner solution,** where the optimal quantity consumed of one good is zero, can occur when a consumer's marginal utility of a good is so low compared to that good's relative price that they are better off not consuming any of that good at all. In such cases, the MRS does not equal the price ratio even though the consumer is at the utility-maximizing consumption bundle. **[**Section 4.4**]**

Review Questions

1. We make four assumptions about preferences: completeness and rankability, “more is better,” transitivity, and consumers’ desire of variety. Briefly describe each assumption.
2. What does the term “utility” mean? How does utility relate to a utility function?
3. Define “indifference curve.” What does an indifference curve tell us about the consumer?
4. We learned that the slope of the indifference curve is called the marginal rate of substitution of *X* for *Y*. What does the Error parsing MathML: error on line 1 at column 938: Opening and ending tag mismatch: img line tell us about a consumer’s preferences between two goods?
5. Why does the slope of the indifference curve vary along the curve? What does this variability tell us about consumers’ preferences?
6. What does a steep indifference curve indicate about a consumer’s preferences? What does a flat indifference curve say?
7. When are two goods perfect substitutes? What does the indifference curve look like, or what is its *curvature*?
8. When are two goods perfect complements? What does the indifference curve look like?
9. In addition to utility, what other factors determine how much of a good to buy?
10. Describe the three assumptions we make when incorporating income into our model of consumer behavior.
11. What is a budget constraint?
12. What determines the slope of a budget constraint? What situation would change the slope of a budget constraint?
13. What do we call the bundle represented by the point of tangency between the consumer’s indifference curve and the consumer’s budget constraint?
14. At the point of tangency, what is true about the ratio of the goods’ marginal utilities and the ratio of their prices?

Problems

1. Which assumption about consumer preferences does each of the following individuals violate?

    a. Adam likes basketball more than football; football more than baseball; and baseball more than basketball.

    b. Kiko prefers prune juice to orange juice but cannot decide how she feels about grapefruit juice.

    c. Blake likes superhero comic books but prefers 5 comic books to 10 comic books.

2. By assumption, individual preferences must be transitive so that if *A* is preferred to *B*, and *B* is preferred to *C*, then *A* is preferred to *C*. Suppose that Marsha, Jan, and Cindy individually have transitive preferences over three goods: oranges, apples, and pears. If Marsha, Jan, and Cindy were to vote on whether to name oranges, apples, or pears the “fruit of the month,” show that it is possible the preferences for the *group* might *not* be transitive.

3. The following table displays the total utility $U(X)$ that corresponds to the number of units of X consumed by three different consumers (Auon, Barbara, and Camira), holding everything else constant:

Auon		Barbara		Camira	
U(*X*)	*X*	*U*(*X*)	*X*	*U*(*X*)	*X*
10	2	10	2	10	2
14	3	10	3	12	3
16	4	10	4	15	4
17	5	9	5	19	5
17.5	6	8	6	24	6

    a. Compute the marginal utility of X for each of the three consumers at each level of X.

    b. Based on the data in the table, can you tell whether any of these consumers are violating any of the standard assumptions about preferences?

    c. Is it possible that any of these three consumers have the same preferences, and that columns for the three consumers differ only because of the arbitrary units that are used to measure utility? Explain.

4. Juliette and Andrew regularly go to the movies, where they like to consume popcorn and slushies. At the movies, Juliette’s utility function is given by
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where P is the number of cups of popcorn and S is the number of slushies she consumes. Andrew’s utility function is given by
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    a. Compute the utility Juliette and Andrew receive from the following combinations of popcorn and slushies:

Units of Popcorn	Units of Slushies	Juliette’s Utility	Andrew’s Utility
1	1		
2	2		
3	3		

    b. Suppose that Juliette and Andrew are each consuming 2 popcorns and 2 slushies. Who gets the most happiness from their movie snacks?

    c. Suppose that Juliette has consumed 2 popcorns and 3 slushies. What is the marginal utility Juliette will receive if she eats another cup of popcorn? What is the marginal utility she will receive if she drinks another slushie?

    d. When Andrew is consuming 1 popcorn and 1 slushie, another popcorn will bring increase his utility by 1 unit. (Verify this!) When Andrew is consuming 8 popcorns and 1 slushie, another popcorn will again increase his utility by 1 unit. Which assumption of consumer preferences might Andrew's particular utility function violate? Does Juliette's utility function appear to violate that assumption, too?

5. Draw two indifference curves for each of the following pairs of goods. Put the quantity of the first good on the horizontal axis and the quantity of the second good on the vertical axis.
   a. Paul likes pencils and pens, but does not care which he writes with.
   b. Rhonda likes carrots and dislikes broccoli.
   c. Emily likes hip-hop iTunes downloads and doesn't care about heavy metal downloads.
   d. Michael only likes dress shirts and cufflinks in 1 to 2 proportions.
   e. Carlene likes pizza and shoes.
   f. Steven dislikes both fish and potatoes.
6. Suppose that John is indifferent between consuming bundle *A,* which consists of 4 apples and 1 peach, and bundle *B,* which consists of 4 peaches and 1 apple. If John were given the choice between bundle *A* and bundle *C,* which contained 3 peaches and 2 apples, which should he pick? (*Hint:* Draw an indifference curve or two.)
7. A consumer's utility function is given by

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   where

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   and

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   a. What is the utility derived from 1 unit of *X* and 2 units of *Y*? What is the utility derived from 2 units of *X* and 1 unit of *Y*? What is the utility derived from 5 units of *X* and 2 units of *Y*?
   b. How does the consumer rank the following bundles?

Bundle	**Quantity of *X***	**Quantity of *Y***
A	2	2
B	10	0
C	1	5
D	3	2
E	2	3

   c. Graph an indifference curve that shows the bundles of *X* and *Y* for which

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   Then graph a second indifference curve for bundles of *X* and *Y* for which

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   Is the "more is better" assumption satisfied for *X* and *Y*?
8. Suppose John's utility function is 4*XY*, where *X* is consumption of beer and *Y* is consumption of pizza. For this utility function, the marginal utility of *X* is given by

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   the marginal utility of *Y* is given by

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   a. Suppose

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   Calculate John's utility for

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   3, 10, and 11. For a given level of *Y*, does good *X* display diminishing marginal utility?
   b. Suppose

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Calculate John’s utility for

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3, 10, and 11. For a given level of *X*, does good *Y* display diminishing marginal utility?

c. Find three different bundles containing *X* and *Y* that give John 48 utils of satisfaction. Plot the three bundles and connect them with an indifference curve. What happens to the marginal rate of substitution between *X* and *Y* as consumption of *X* increases?

d. Does the principle of diminishing MRS depend on the diminishing marginal utility of *X* and *Y*?

9. Carmen is a writer who enjoys writing with both pencils and pens. Her utility function for pencils and pens is given by

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where *X* is the number of pencils she has and *Y* is the number of pens. Carmen currently has 2 pencils and 4 pens.

a. Calculate Carmen’s current utility.

b. What is the marginal utility of an additional pencil,

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An additional pen,

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c. Find two other bundles of pencils and pens that would give Carmen the same level of satisfaction she currently has, and connect the dots to create an indifference curve. Does the indifference curve have a special shape? Why might it have this shape?

d. The marginal rate of substitution (MRS) is measured as the slope of an indifference curve. Calculate the MRS at Carmen’s current consumption level. Does it equal the ratio of marginal utilities,

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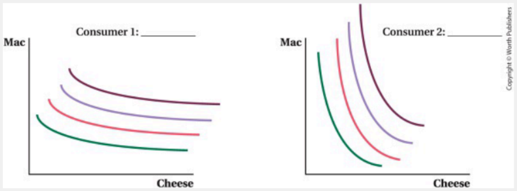
10. Joey likes macaroni well enough and really loves cheese. Phoebe likes cheese well enough, but really loves macaroni. Below are two sets of indifference curves for two different consumers. Determine which set of indifference curves belong to Joey, and which belong to Phoebe.



11. José gets satisfaction from both music and fireworks. José’s income is $240 per week. Music costs $12 per album, and fireworks cost $8 per bag.

a. Graph the budget constraint José faces, with music on the vertical axis and fireworks on the horizontal axis.

b. If José spends all his income on music, how much music can he afford? Plot a point that illustrates this scenario.

c. If José spends all his income on fireworks, how many bags of fireworks can he afford? Plot a point that illustrates this scenario.

d. If José spends half his income on fireworks and half his income on music, how much of each can he afford? Plot a point that illustrates this scenario.

e. Connect the dots to create José’s budget constraint. What is the slope of the budget constraint?

f. Divide the price of fireworks by the price of music. Have you seen this number before while working on this problem, and if so, where?

g. Suppose that a holiday bonus temporarily raises José's income to $360. Draw José's new budget constraint.

h. Indicate the new bundles of music and fireworks that are feasible, given José's new income.

12. Taj enjoys ordering out for pizza and renting movies online. He makes $30 each week at a part-time job. If movies cost $2 per rental and pizza costs $7.50 per slice, graph Taj's budget constraint. Then illustrate the effects of each of the following events:

    a. Taj's mother finds a coupon good for 1 free pizza at a local chain and gives it to Taj.

    b. The company from which Taj rents movies sponsors a holiday week promotion: Rent the first 5 movies at their regular price, and all movies after the fifth are half off.

    c. Taj's favorite pizzeria increases the price of a slice from $7.50 to $10.

13. Sydney earns $100 from his YouTube videos each week; he spends it all on concert tickets and paintball.

    a. If concert tickets cost $20 each and paintball admission is $10 per session, graph Sydney's budget constraint.

    b. Suppose Sydney's YouTube haul increases to $200 per week. Graph Sydney's new budget constraint.

    c. Suppose Sydney's YouTube income remains steady at $100, but the price of concert tickets decreases to $10 and the price of paintball to $5. Graph Sydney's new budget constraint.

    d. Is there a fundamental difference between a doubling of income and a halving of prices? Explain.

    e. Would there be a difference in feasible bundles if the price of concert tickets was cut to $10, but the price of paintball remained the same?

14. During World War II, gasoline sold for a then-unfathomable $0.20 per gallon. Suppose that Rosie works part-time and earns an average of $4 each week to spend on gasoline and food, which costs $0.50 per serving.

    a. Graph Rosie's budget constraint, putting gasoline on the vertical axis and food on the horizontal axis.

    b. During World War II, ordinary citizens were allowed to purchase only 3 gallons of gasoline each week. Show the effects of this quantity restriction on Rosie's budget constraint.

15. Caitlin spends her money on tuition and books. One credit hour of tuition costs her $320; each book costs her $200. Currently, the marginal utility of a credit hour to Caitlin is 80; the marginal utility of another book is 40.

    a. Is Caitlin maximizing her utility?

    b. Should Caitlin buy more books and enroll in fewer credit hours?

16. André gets utility from playing laser tag and reading books. Each week, André spends his entire $100 paycheck on both goods. One hour of laser tag costs $20; a book costs $10.

    a. Graph André's budget constraint. Put books on the horizontal axis and hours of laser tag on the vertical axis.

    b. When André maximizes his utility, he buys 6 books. Carefully add an indifference curve to your graph to reflect André's utility-maximizing bundle of books and laser tag.

    c. When André maximizes his utility, how many hours of laser tag does he play?

    d. When André maximizes utility, the marginal utility he receives from playing an extra hour of laser tag is 12 utils. How much utility must André get from reading another book?

17. For Maahir, shampoo and conditioner are perfect complements. He likes to use 1 squirt of shampoo and 1 squirt of conditioner each time he washes his hair.
    a. Draw a set of indifference curves for Maahir that illustrate the utility he derives from using shampoo and conditioner.
    b. Assume that shampoo costs $4 and conditioner costs $2. Construct a budget constraint for Maahir and describe his purchasing habits. What is his optimal bundle likely to look like? (*Hint:* Assume some level of income for Maahir.)
    c. Suppose that prices change so that shampoo costs $2 and conditioner costs $4. What is likely to happen to Maahir's optimal bundle as a result? Explain.
    d. How would your answer to (c) change if Maahir used 2 squirts of shampoo and 1 squirt of conditioner each time he washed his hair?
18. Suppose that there are only two goods, books and coffee. Justine gets utility from both books and coffee, but her indifference curves between them are concave rather than convex to the origin.
    a. Draw a set of indifference curves for Justine.
    b. What do these particular indifference curves tell you about Justine's marginal rate of substitution between books and coffee?
    c. What will Justine's utility-maximizing bundle look like? (*Hint:* Assume some level of income for Justine and some prices for books and coffee; then draw a budget constraint.)
    d. Compare your answer to (c) to real-world behaviors. Does the comparison shed any light on why economists generally assume convex preferences?
19. Chrissy spends her income on fishing lures (L) and guitar picks (G). Lures are priced at $2, while a package of guitar picks costs $1. Assume that Chrissy has $30 to spend and her utility function can be represented as

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    a. What is the optimal number of lures and guitar picks for Chrissy to purchase? How much utility does this combination give her?
    b. If the price of guitar picks doubles to $2, how much income must Chrissy make to maintain the same level of utility?
20. A popular cellular telephone provider offers its customers the following pay-as-you-go data plan: The first 4 gigabytes of data cost $10 each; each gigabyte of data after that costs $20.
    a. Suppose the typical data customer has $100 to spend on either phone use or chocolate bars, which cost $1 each. Graph the typical customer's budget constraint.
    b. Add an ordinary-looking (downward-sloping, convex to the origin) set of indifference curves to the graph, to represent the preferences of the typical customer. How many gigs of data is the typical customer likely to use?
    c. Does your answer to (b) depend critically on the steepness or flatness of the typical customer's indifference curves? Explain.
21. Cherise considers movies and concerts to be perfect substitutes. When Cherise maximizes her utility, what will the optimal bundle of movies and concerts probably look like? Explain your reasoning by drawing a graph that includes her indifference curves and a hypothetical budget constraint.
22. Consider Joey and Phoebe, our mac and cheese lovers from Problem 10. Comment on the following statement: *Because Joey really loves cheese, when he maximizes his utility, he will be willing to give up more mac to get another cheese than Phoebe will.*

Appendix 4A:

The Calculus of Utility Maximization and Expenditure Minimization

In the chapters you've read so far, you've probably noticed that we use several different approaches when explaining microeconomic theories and applications. One method is mainly intuitive: Tell a story to illustrate an economic concept or discuss the logic of a model and its implications. This method of economic analysis goes back to Adam Smith's description of the "invisible hand" that shapes economic markets. A second method is the graphical approach. You only have to say "supply and demand" to conjure up a simple but powerful representation of a market. Finally, you've seen some simple mathematical models such as the algebraic representations of supply and demand curves in Chapter 2 and the consumer's budget constraint in Chapter 4. Each of these approaches provides a different window into understanding economic concepts.

Those of you who are familiar with calculus have yet another way to approach microeconomics. The tools of calculus are a natural fit with economics, and most economic models are formally derived using calculus. For some people (especially economists), it's easy to become so caught up in the math that the real economic ideas get lost. We don't want you to fall into that trap. That's why we present the calculus as a supplement to the intuition that we develop in the chapter. The calculus appendices provide an additional set of tools to examine the economic decisions and interactions discussed in the chapter. The logic of the models and the intuition from the chapter are still here in the calculus, only in another form.

So, don't think of the calculus that we explore in the appendices as a substitute for the logic, graphs, and algebra we use to explain microeconomics in the chapters. Instead, think of these techniques and the calculus as complements. As you learn more about microeconomics, you will find that each of these different approaches to understanding microeconomics may be more or less useful depending on the circumstances.

4A.1 Consumer's Optimization Problem

One of the topics for which calculus provides additional insight is consumer behavior. Let's start by recalling the answer to the consumer's problem that we derived graphically in the chapter before seeing how we can get there using calculus. A consumer maximizes their utility $U(X,Y)$ when

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You may have noticed that to solve the optimization problem in the chapter, we just gave you the consumer's marginal utilities of goods X and Y—we didn't actually solve for them. This is because solving for the marginal utilities requires more than just the algebra and geometry we've relied on so far. Calculus allows us to derive the marginal utilities directly from the consumer's utility function. After determining the values of the marginal utilities, we can calculate the marginal rate of substitution. Calculus also provides us with another way to solve the consumer's problem—the Lagrangian—which yields some important insights into utility maximization.

4A.2 The Marginal Rate of Substitution and Marginal Utility

In the chapter, we develop the connection between the marginal rate of substitution and marginal utility by thinking about how utility from each good changes as the consumer moves a little bit along one of their indifference curves. Here, we work in the opposite direction by starting with utility and seeing how we can use calculus to find the MRS. In this way, we examine what happens when we make small changes to the consumption bundle.

Take the consumer who has utility for goods X and Y, $U(X,Y)$. Any of the consumer's indifference curves show how the consumer trades off good X for good Y while keeping utility constant. We can choose any one of these indifference curves and call its level of utility

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We are interested in how the utility from each good changes as we change the quantities of *X* and *Y*. So, we will totally differentiate the utility function, setting the total change in utility, *dU*, equal to zero because we are holding the level of utility constant:

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The right-hand side of this equation,
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is the negative of the slope of the indifference curve or the marginal rate of substitution. Therefore,

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4A.3 Utility Maximization

The ratio of the marginal utilities is one piece of the puzzle—the preferences side. To finish the consumer's optimization, we need to relate consumer preferences to the prices of the goods and the consumer's income. Let's start by looking at a consumer whose utility function is the standard Cobb–Douglas functional form,
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where
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and whose income is
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This consumer's utility-maximization problem is written formally as

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This is known as a *constrained optimization problem*, in which *U*(*X*,*Y*) is the objective function and
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is the constraint. In other words, how much utility the consumer can get is *constrained* by how much income they have to spend. In the chapter, we solved the same constrained optimization problem graphically with the objective of reaching the highest indifference curve while staying on the budget constraint.

If this were an unconstrained maximization problem, finding the optimal combination of variables would be fairly straightforward: Take the partial derivatives of the objective function with respect to each of the variables, set them equal to zero, and solve for the variables. But the presence of the budget constraint complicates the solution of the optimization problem (although without the constraint there wouldn't even be a finite solution to the utility-maximization problem because in an unconstrained world, the consumer consumes infinite amounts of each good).

There are two approaches to solving the consumer's utility-maximization problem using calculus. The first relies on what we already demonstrated in this chapter: At the optimum, the marginal rate of substitution equals the ratio of the two goods' prices. First, take the partial derivatives of the utility function with respect to each of the goods to derive the marginal utilities:

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Next, use the relationship between the marginal utilities and the marginal rate of substitution to solve for
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and simplify the expression:

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Find *Y* as a function of *X* by setting
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equal to the ratio of the prices:

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Now that we have the optimal relationship between *Y* and *X*, substitute the expression for *Y* into the budget constraint to solve for the optimal consumption bundle:

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You can see that the resulting optimal bundle
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is dependent on all three pieces of the consumer's problem: the consumer's relative preferences
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the consumer's income *I*, and the goods' prices
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4A.4 Utility Maximization Using the Lagrangian

The first approach to finding the optimal consumption bundle is precisely the method we used in the chapter; the only difference is that we used calculus to derive the marginal utilities and then solved for the marginal rate of substitution. A second approach introduces something known as the Lagrange multiplier, or
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The Lagrangian is a technique for transforming a constrained optimization problem into an unconstrained problem by combining the objective function and the constraint into one equation.
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is a variable that multiplies the constraint.

Suppose, for example, that the objective function is *f*(*x*, *y*) and the constraint is
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The Lagrangian equation is

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Now maximize the equation by taking the partial derivatives of the equation with respect to *x*, *y*, and
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and set them equal to zero. Partial derivatives in this form are known as first-order conditions, or FOC:

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So, we have three equations and three unknowns and can solve the system of equations. Note that the third first-order condition is simply the constraint.

Let's see how the Lagrangian can be applied to our consumer facing the utility-maximization problem:

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(Notice that we wrote the budget constraint so that it is equal to zero—this is important for how we set up the Lagrangian.) This equation can be rewritten in Lagrangian form as

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Take the first-order conditions (FOCs):

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Embedded in these three first-order conditions are the same three pieces of information we've seen before: the marginal utilities of *X* and *Y*, the goods' prices, and the consumer's income.

The Lagrange multiplier

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is in the first two first-order conditions. So, solve each of these equations for
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How can we interpret this Lagrange multiplier? First, recognize that the numerators are the marginal utilities of *X* and *Y*. In other words, at the optimum,
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Therefore,
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is the exchange rate between utility and income—an additional dollar of income allows the consumer to purchase additional goods that generate
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more units of utility. We can also see this in the Lagrangian: If income increases by $1, maximum utility increases by
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units. In other words,
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measures the marginal utility of income. For example, let's say that
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is 0.5. Then, if you gain $1 more in income, you'll gain 0.5 units of utility.

Note that this expression for
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is the optimization condition in terms of the consumer's marginal utility per dollar spent that we derived in the chapter. We can rearrange this to get exactly what we showed graphically in the text—that the marginal rate of substitution equals the ratio of the prices:

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We can then solve for (*X**, *Y**) exactly as we did in the first approach, starting by finding *Y* as a function of *X* using the equality from the first two conditions:

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Using the last first-order condition, we can plug this value for *Y* into the budget constraint:

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figure it out 4A.1

Let's revisit Figure It Out 4.4. Antonio gets utility from burgers (*B*) and fries (*F*) in the form

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His income is $20, the price of burgers is $5, and the price of fries is $2.

Find Antonio's optimal consumption bundle.

Solution:

To find the optimal consumption bundle, we need to solve the consumer's utility-maximization problem:

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The solution in the chapter uses the approach in which we solve for the
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from the marginal utilities. If instead we use the Lagrangian, we begin by writing Antonio's constrained optimization problem and then solve for the first-order conditions:

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FOC:

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Use the first two conditions to solve for
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Set the two expressions for
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equal to each other and solve for *F* as a function of *B*:

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So, for every burger Antonio consumes at the optimum, he will consume 2.5 orders of fries. Substitute
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into the third condition (the consumer's budget constraint) and solve for the optimal bundle (B^*,F^*):

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This is where we stopped when we solved Antonio's constrained optimization problem using the first approach we presented in this appendix. But using the Lagrangian, we can also solve for one more variable: the marginal value of Antonio's income,
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when Antonio is maximizing his utility.

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Therefore, Antonio's utility increases by 0.16 units of utility for every extra dollar of income he has.

4A.5 Expenditure Minimization

As we saw in the chapter, utility maximization—where you take income as given and find the combination of goods that will give you the greatest utility—is only one way to look at the consumer's optimization problem. Another is expenditure minimization, in which you start with a level of utility and find the cheapest bundle that achieves that utility level. In many ways, expenditure minimization is less intuitive—in real life, you probably do face a set income, but no contract you sign will ever specify your utility. But, ultimately, expenditure minimization leads to the same answer. What is more, the expenditure-minimization technique will be extremely useful when you get to the appendices for Chapters 5 and 7. In particular, this technique makes a lot more sense in the context of the producer's cost-minimization problem in Chapter 7.

Let's demonstrate the equivalence of utility maximization and expenditure minimization using Antonio's utility function from Figure It Out 4.4 and the Lagrangian method (the first approach is identical to that for utility maximization except that you plug into the utility constraint instead of the budget constraint in the last step). We write out Antonio's expenditure-minimization problem given a constant utility of
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or
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the utility at his optimal consumption bundle from the utility-maximization problem above:

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or

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As before, solve for the first-order conditions:

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Then solve for
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in the first two conditions:

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Set the two expressions for
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equal to each other and solve for *F* as a function of *B*:

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Now substitute *F* as a function of *B* into the utility constraint:

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This optimal bundle of goods costs Antonio

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the minimum expenditure needed to achieve
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units of utility.

Expenditure minimization is a good check of our cost-minimization problem because it should yield the same results. In this case, as with utility maximization, Antonio purchases 2 burgers and 5 orders of fries for a cost of $20 and a total utility of
Error parsing MathML: error on line 1 at column 878: Opening and ending tag mismatch: img line 0 and an

Problems

1. For the following utility functions,
    - Find the marginal utility of each good.
    - Determine whether the marginal utility decreases as consumption of each good increases (i.e., does the utility function exhibit diminishing marginal utility in each good?).
    - Find the marginal rate of substitution.
    - Discuss how
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      changes as the consumer substitutes *X* for *Y* along an indifference curve.
    - Derive the equation for the indifference curve where utility is equal to a value of 100.
    - Graph the indifference curve where utility is equal to a value of 100.

    a. Error parsing MathML: error on line 1 at column 1617: Opening and ending tag mismatch: img
    b. Error parsing MathML: error on line 1 at column 1892: Opening and ending tag mismatch: img
    c. Error parsing MathML: error on line 1 at column 1861: Opening and ending tag mismatch: img
2. Suppose that Maggie cares only about chai and bagels. Her utility function is
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   where *C* is the number of cups of chai she drinks in a day, and *B* is the number of bagels she eats in a day. The price of chai is $3, and the price of bagels is $1.50. Maggie has $6 to spend per day on chai and bagels.
    a. What is Maggie’s objective function?
    b. What is Maggie’s constraint?
    c. Write a statement of Maggie’s constrained optimization problem.
    d. Solve Maggie’s constrained optimization problem using a Lagrangian.
3. Suppose that there are two goods, *X* and *Y*. The price of *X* is $2 per unit, and the price of *Y* is $1 per unit. There are two consumers, *A* and *B*. The utility functions for the consumers are
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Consumer *A* has an income of \$100, and Consumer *B* has an income of \$300.

   a. Use Lagrangians to solve the constrained utility-maximization problems for Consumer *A* and Consumer *B*.
   b. Calculate the marginal rate of substitution for each consumer at their optimal consumption bundles.
   c. Suppose that there is another consumer (let’s call them Consumer *C*). You don’t know anything about Consumer *C*’s utility function or their income; all you know is that they consume both goods. What do you know about *C*’s marginal rate of substitution at their optimal consumption bundle? Why?

4. Katie likes to paint and sit in the sun. Her utility function is

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   where *P* is the number of paint brushes and *S* is the number of straw hats. The price of a paint brush is \$1 and the price of a straw hat is \$5. Katie has \$50 to spend on paint brushes and straw hats.

   a. Solve Katie’s utility-maximization problem using a Lagrangian.
   b. How much does Katie’s utility increase if she receives an extra dollar to spend on paint brushes and straw hats?

5. Suppose that a consumer’s utility function for two goods (*X* and *Y*) is

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   The price of good *X* is \$5 per unit and the price of good *Y* is \$10 per unit. Suppose that the consumer must have 80 units of utility and wants to achieve this level of utility with the lowest possible expenditure.

   a. Write a statement of the constrained optimization problem.
   b. Use a Lagrangian to solve the expenditure-minimization problem.

Appendix 4B:

The Mathematics of Utility Functions

We saw in the text that utility functions and indifference curves are different ways to represent a consumer’s preferences. Calculus can help us make the connection between the two curves more explicit. In fact, in this appendix we see that we can derive indifference curves directly from a consumer’s utility function.

It’s easiest to show this derivation by beginning with a specific utility function. Let’s look at a consumer with the utility function

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where *X* and *Y* are two goods. Any consumer’s indifference curve shows all the bundles of goods that generate the same level of utility. For our consumer, let’s say that utility level is 300 utils:

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What does this formula tell us? It is precisely the consumer’s indifference curve at 300 utils. We could stop here, but graphing a function is usually easier if we rewrite it with *Y* as a function of *X*. So, first we solve for *Y*:

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Figure 4B.1 graphs this function to display the consumer’s indifference curve at 300 utils.

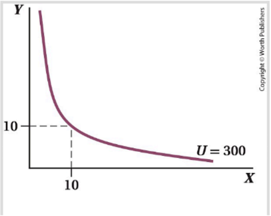

Figure 4B.1 An Indifference Curve at 300 Utils

The slope of this indifference curve decreases as the consumer trades off *Y* for *X*, or as she consumes fewer units of *Y* and more of *X*. In other words, as she moves down her indifference curve, the consumer has to receive more of *X* as she gives up units of *Y* in order to stay on the same indifference curve.

We can confirm this relationship by calculating the marginal rate of substitution (*MRS*) from the utility function using calculus. First, find the marginal utilities by taking the partial derivative of the utility function with respect to each of the goods:

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Then use the marginal utilities to calculate the *MRS*:

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Now that we have the marginal rate of substitution, we can find out what happens to the relative consumption of *X* and *Y* as we move along the consumer's indifference curve. To see what occurs as *X* increases, we take the partial derivative of Error parsing MathML: error on line 1 at column 998: Opening and ending tag mismatch: img line 0 and an with respect to *X*:

Error parsing MathML: error on line 66 at column 30: Opening and ending tag mismatch: img line 0 and a

Just as the graph demonstrates, the consumer's marginal rate of substitution—the slope of the indifference curve—decreases as her consumption of *X* increases along the indifference curve. In other words, when the consumer has more units of *X*, she is willing to give up fewer units of *Y* to get an additional unit of *X*; while keeping her utility level constant.

4B.1 figure it out

Suppose that a consumer has the following utility function:

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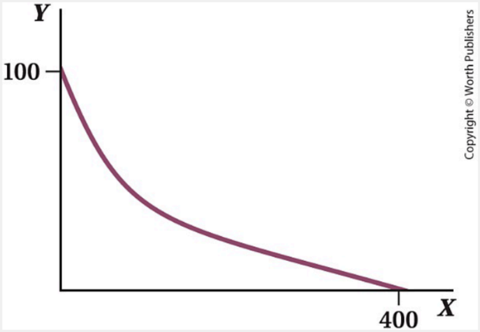
a. Graph the indifference curve generated by the utility function when Error parsing MathML: error on line 1 at column 942: Opening and ending tag mismatch: img line 0 and annotation-xml
b. Find the marginal rate of substitution and relate the shape of the indifference curve to it.

Solution:

a. First, set the utility function equal to 100 units and solve for *Y* as a function of *X*: Error parsing MathML: error on line 1 at column 3204: Opening and ending tag mismatch: img line 0 and annotation-xml

   Notice that either *X* or *Y* may equal zero; therefore, the indifference curve intersects both axes. The vertical intercept is 100 units of *Y*, and the horizontal intercept is 400 units of *X*.



b. The graph indicates that the slope of the indifference curve decreases as the consumer gives up *Y* to get more *X*. Therefore, the *MRS* is decreasing. Let's confirm this by calculating the marginal rate of substitution. First, find the marginal utilities: Error parsing MathML: error on line 1 at column 9373: Opening and ending tag mismatch: img line 0 and annotation-xml

   Now find the marginal rate of substitution:

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Finally, take the partial derivative of this marginal rate of substitution with respect to *X* to see how the *MRS* is altered with changes in *X*:

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Therefore, the *MRS* decreases as the consumption of *X* increases along the indifference curve; as shown in the figure.

Monotonic Transformations of Utility Functions

A utility function is a convenient way to represent preferences. However, we saw in the chapter that utility functions have many limitations. One limitation is that although utility functions tell us a lot about the ordinal rankings of goods, they reveal nothing about cardinal rankings. In other words, we know what a consumer prefers, but not the strength of that preference. Because of this, we can shift, stretch, or squeeze the utility function into any form as long as we don't change the ordering of preferences over bundles, and we'll still have the same representation of the relative utility of goods. This type of transformation is termed a *monotonic transformation*. Monotonic transformations tell us a great deal about the properties of utility functions, and so it's worth going into more detail about these types of transformations here.

Some monotonic transformations are simple. Adding or subtracting a fixed number of "utils" from a utility function doesn't change the ordering of the preferences. It just makes the utility level shift up or down by some constant number of units. Multiplying a utility function by any positive number is also simple. This change multiplies the number of units of utility by that positive number without changing their order. The same goes for exponents. As long as we apply the same positive exponent to the whole utility function, we just increase or decrease the number of utils by that exponent without changing the order.[1] Let's try to make this more concrete with a specific example.

Consider the utility function
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and the following two bundles: bundle A has 4 units of *X* and 16 units of *Y* (4, 16), and bundle *B* has 9 units of *X* and 4 units of *Y* (9, 4). The consumer prefers bundle *A* to bundle *B* because bundle *A* generates 8 units of utility and *B* generates 6 units of utility. Now let's consider some monotonic transformations of $U(X,Y)$. Suppose we multiply the utility function by 37 to get
Error parsing MathML: error on line 1 at column 2028: Opening and ending tag mismatch: img line 0 and a
The consumer still prefers A with 296 units of utility to B with 222 units of utility. What if we square the original utility function to get
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Then she still prefers *A* to *B* (64 versus 36 units of utility). In each of these transformations, the only thing that changes is the number of units of utility.

Checking the ordering of many bundles by plugging them into the transformed utility functions is impractical. Therefore, we need another way to show us whether the transformation preserves the preference ordering.

Let's think about these transformations in terms of indifference curves. The utility function determines the shape of the indifference curve and assigns a number to the level of utility represented by each indifference curve. We have already discussed how the number assigned to the level of utility doesn't matter. As long as the number assigned to the level of utility increases as we move away from the origin, the preference ranking is preserved.

What does matter is the shape of the indifference curve. If a transformation makes the indifference curves steeper or flatter, then the ordering of bundles on the new indifference curves will be very different from the original ordering of those bundles, and the transformation cannot be monotonic.

How do we know if the shape of the indifference curves is preserved? By looking—once again—at the marginal rate of substitution. Recall that the *MRS* is the negative of the slope of the indifference curve at any bundle and is equal to the ratio of the marginal utilities at that point. If the marginal rate of substitution at any point doesn't change, we know that we have a monotonic transformation.

Let's go back to our example from above, where
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For this utility function,

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What if we transform the utility function by squaring and then taking the natural log? Then,

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This certainly looks very different from our original function. In fact, though, we can solve for the *MRS* to see that it is a monotonic transformation (recall that the derivative of ln(*Z*) with respect to *Z* is 1/*Z*):

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The equal marginal rates of substitution tell us that the shapes of the indifference curves are the same for *U*(*X*,*Y*) and
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Therefore,
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is a monotonic transformation of *U*(*X*,*Y*), and the two utility functions represent the same set of preferences.

Let's take the lessons learned from these examples and see if we can demonstrate a general principle of monotonic transformations of Cobb—Douglas utility functions, the form of the original utility function we presented here. For a generic Cobb—Douglas utility function
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the marginal rate of substitution is

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When will a transformation be monotonic for a Cobb—Douglas utility function? Examining the fraction above, we can see that any transformation of the Cobb-Douglas utility function will be a monotonic transformation as long as the ratio of
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to
Error parsing MathML: error on line 1 at column 620: Opening and ending tag mismatch: img line 0 and an
does not change. The magnitude of the exponents doesn't matter. The only thing that matters is the relative size of the exponents. For example, multiplying both exponents by any real number would not change the ratio of
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to
Error parsing MathML: error on line 1 at column 684: Opening and ending tag mismatch: img line 0 and an
Therefore, we could raise the utility function to any power without changing the preference ordering.

4B.2 figure it out

Royce only cares about how much coffee he drinks. He can buy coffee in 10-ounce cups or in 20-ounce cups. Royce's preferences are represented by the following utility function:

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where *X* is the number of 10-ounce cups and *Y* is the number of 20-ounce cups. Determine whether or not Royce's preferences could also be represented by this utility function:

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Solution:

Notice that Royce views these goods as perfect substitutes and that he is twice as happy with a 20-ounce cup of coffee as he is with a 10-ounce cup of coffee. Take the partial derivatives to get the marginal utilities:

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So, the marginal utility of each good is constant, and an additional unit of *Y* is twice as good as an additional unit of *X*. Consequently, the marginal rate of substitution is

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indicating that Royce is always willing to trade
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of a 20-ounce cup for another 10-ounce cup.

We can determine whether the second utility function is a monotonic transformation of the original utility function by comparing the marginal rates of substitution. First, find the marginal utilities:

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Notice that the marginal utilities for the transformed utility function are very different from the original marginal utilities. However, marginal utilities are not the deciding factor in determining whether Royce's preferences can be represented by the second utility function; the equality of the marginal rates of substitution tells us whether the second utility function is a monotonic transformation of the first.

We now may find the marginal rate of substitution:

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which is exactly the same as the marginal rate of substitution for the original utility function. Therefore, the utility functions are monotonic transformations of one another and represent the same set of preferences even though the numbers we assign to the utility levels are very different.

Corner Solutions

A solution to the utility-maximization problem is an "interior" solution if the consumption bundle contains at least some of each good, because such a bundle will be located in the interior of the *X*-*Y* plane. Almost all the utility-maximization problems we have seen in the chapter have interior solutions. There is another possibility, however: A consumer may be better off consuming just one good and not consuming any of the other. Economists call this a "corner solution," and we'll consider these solutions to the utility-maximization problem here.

Let's consider, however, why we more commonly see interior solutions. Consider what is probably the most commonly seen utility function in economics: the Cobb—Douglas utility function,
Error parsing MathML: error on line 1 at column 1958: Opening and ending tag mismatch: img line 0 and a
Utility here is only maximized when the consumption of both goods is positive and nonzero. It's fairly easy to see why. If a consumer consumes none of one good (say, she consumes 0 units of *X*), then
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As a result, utility is never maximized at a corner solution. This is true of more than just Cobb –Douglas functions: Any time you are working with a utility function that gives zero utility whenever one good is not consumed, you will have an interior solution.

To have a corner solution, the utility function must result in positive utility when the consumer only consumes one good. In the chapter, we saw one such set of indifference curves where corner solutions are possible in Figure 4.20. In that illustration, Greg is a consumer of romance novels *R* and economics textbooks *T*. Let's say that Greg faces the following utility function:

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where *R* is the quantity of romance novels and *T* is the quantity of economics textbooks. A corner solution is possible with this utility function, but it is of a particular type. Greg may consume all economics texts and no romance novels; then his utility is

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Therefore, a corner solution is possible. If Greg consumes 0 economics textbooks, however, his utility goes to 0. As a result, we know that Greg's utility-maximizing bundle may have 0 romance novels, but must have textbooks.

Let's solve a utility-maximization problem to illustrate this. Suppose that Greg faces the budget constraint drawn in Figure 4.20: He has $240 to spend on the goods, a romance novel costs $20, and the price of an economics textbook is $120. In this case, Greg solves the following constrained optimization problem:

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We can write his problem as a Lagrangian and take the first-order conditions:

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FOC:

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Solve for
Error parsing MathML: error on line 1 at column 624: Opening and ending tag mismatch: img line 0 and an
in the first two FOCs:

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and

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Set these expressions for
Error parsing MathML: error on line 1 at column 624: Opening and ending tag mismatch: img line 0 and an
equal to each other and solve for *T* as a function of *R*:

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Now plug this expression for *T* into the third FOC:

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So, Greg's optimal number of romance novels is – 4. That is impossible, so Greg will do the next best thing. He will choose one of the corners of his budget constraint—a corner solution—where he consumes 0 romance novels and 2 economics textbooks. Note that this bundle does not satisfy our utility-maximization condition in which the marginal rate of substitution is equal to the ratio of the prices (or where the indifference curve and budget constraint are tangent), but it's as close as Greg can get to his utility-maximizing bundle under these conditions.

Sometimes choosing one corner of the budget constraint is obvious, as in the case where the consumer wants a negative number of one of the goods. But there's another type of problem that will yield a corner solution. We'll see this in the Figure It Out below.

4B.3 figure it out

Recall from the previous Figure It Out that Royce has the utility function

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where *X* is the number of 10-ounce cups of coffee and *Y* is the number of 20-ounce cups of coffee. Suppose Royce has $6 to spend on coffee each day and that the price of a 10-ounce cup is $2 and the price of a 20-ounce cup is $3. Find Royce's optimal bundle of 10-ounce and 20-ounce cups of coffee.

Solution:

We could write out Royce's constrained optimization problem and solve the Lagrangian, but let's instead apply the utility-maximization condition we derived in the chapter and in the appendix:

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In this problem,

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but

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so there is no way that the utility-maximization condition will be met. Royce will either want to consume all 10-ounce cups or all 20-ounce cups. The easiest way to determine which he will choose is to calculate Royce's utility at each corner of his budget constraint. If he only buys 10-ounce cups, he will get 3 cups and 3 units of utility. On the other hand, he could buy two 20-ounce cups and get 4 units of utility. He is better off with the 20-ounce cups so that will be the corner solution to his problem.

Problems

1. For the following utility functions,
   - find the marginal rate of substitution,
   - discuss how Error parsing MathML: error on line 1 at column 1048: Opening and ending tag mismatch: img changes as the consumer substitutes *X* for *Y* along an indifference curve,
   - derive the equation for the indifference curve where utility is equal to a value of 100, and
   - graph the indifference curve where utility is equal to a value of 100:

   a. Error parsing MathML: error on line 23 at column 42: Opening and ending tag mismatch: img li

   b. Error parsing MathML: error on line 23 at column 42: Opening and ending tag mismatch: img li

   c. Error parsing MathML: error on line 27 at column 42: Opening and ending tag mismatch: img li

2. Suppose that Renée consumes 2 goods, *X* and *Y*, and that her preferences are represented by the utility function Error parsing MathML: error on line 1 at column 1984: Opening and ending tag mismatch: img line Determine whether each of the following utility functions also represent Renée's preferences:

   a. Error parsing MathML: error on line 23 at column 42: Opening and ending tag mismatch: img li

   b. Error parsing MathML: error on line 31 at column 42: Opening and ending tag mismatch: img li

3. Suppose that a consumer has a choice between gallon jugs of milk and half-gallon jugs of milk. The consumer only cares about how much milk she consumes and does not care about the size of the jug.

   a. Write a utility function for this consumer.

   b. Suppose the price of a half-gallon jug of milk is \$2, the price of a gallon jug of milk is \$5, and the consumer has \$10 to spend on milk. Set up a Lagrangian and derive the first-order conditions for the maximization problem.

   c. Is there a solution to the first-order conditions? If so, solve for the optimal quantities of gallon jugs and half-gallon jugs. If not, what is the solution to the maximization problem?

4. Terry has \$100 to spend on lake perch and walleye for his family's Friday fish fry. Terry's utility function is Error parsing MathML: error on line 23 at column 36: Opening and ending tag mismatch: img line

   where *P* is pounds of lake perch and *W* is pounds of walleye.

   a. Suppose the price of perch is \$5 per pound and the price of walleye is \$3 per pound. Find Terry's optimal combination of perch and walleye.

   b. Suppose that the price of perch increases to \$12 per pound, while the price of walleye remains unchanged. Find Terry's optimal combination of perch and walleye.

CHAPTER 5
Individual and Market Demand

5.1 How Income Changes Affect an Individual's Consumption Choices
5.2 How Price Changes Affect Consumption Choices
5.3 Consumer Responses to Price Changes: Substitution and Income Effects
5.4 The Impact of Changes in Another Good's Price: Substitutes and Complements
5.5 Combining Individual Demand Curves to Obtain the Market Demand Curve
5.6 Conclusion
Appendix 5A The Calculus of Income and Substitution Effects
Appendix 5B The Calculus of Demand

In Chapter 4, we learned the basics of how consumers make choices: Preferences (embodied in the consumer's utility function and its associated indifference curves) along with income and market prices (both embodied in the consumer's budget constraint) pin down the consumer's utility-maximizing bundle of goods. Variations in preferences show up in the shapes of indifference curves, and variations in income and prices in the location and slope of the budget constraint. With that consumer choice framework, we can see exactly where the demand curves we used in Chapters 2 and 3 come from, when they shift, and how to add up individual consumers' demands to get market demand curves.

Because demand is half the story in any market, knowing what determines and drives consumer demand is crucial to understanding a number of issues, including:

- why shifts in tastes affect prices,
- the benefits that products offer consumers,
- what happens to purchase patterns as consumers (or even entire countries) become wealthier,
- how changes in the price of one good affect the demand for other goods, and
- what factors determine consumers' responses to price changes.

Samsung's chief marketing officer, for example, needs to know all these things about smartphones when making the company's plans for a new model.

We start this chapter by looking at what happens to a consumer's choices when prices stay fixed but income goes up or down. This analysis involves finding the consumer's optimal bundle not just once for a particular income level (as we did in Chapter 4), but over and over for every possible amount of income.

Next, we determine how a consumer's chosen bundle changes as the price of one good in the bundle changes (holding the other prices and income constant). Analyzing how the quantity desired of a good changes as the price of that good changes maps out an individual consumer's demand curve for that good. We'll see that consumers' responses to price changes have two components: the change in relative prices caused by the price change and the change in the purchasing power of the consumer's income caused by the price change.

We then see how changes in the price of *other* goods affect the consumer's decision about how much of a particular good to consume. This effect can increase or decrease the quantity of a good demanded, depending on whether one good is a substitute for the other or if the two goods are consumed together.

After we explore all these features of an *individual's* choices, we show how total *market* demand responds to the same changes. Once this is done, we'll have arrived at a full understanding of what determines the market demand that we took as given in Chapters 2 and 3.

5.1 How Income Changes Affect an Individual's Consumption Choices

In Section 4.3, we learned how changes in income affect the position of a consumer's budget constraint. Lower incomes shift the constraint toward the origin; higher incomes shift it out. In this section, we look at the **income effect**, the change in a consumer's consumption choices that results from a change in the purchasing power of the consumer's income. To isolate this effect, we hold everything else constant during our analysis. Specifically, we mean that relative prices don't change and the consumer's preferences (reflected in the utility function and its associated indifference curves) stay the same. We just increase income and see what happens. **Figure 5.1** shows the effect of an increase in income on consumption for Eve, a consumer who allocates her income between vacations and tickets to basketball games. Her initial budget constraint

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is tangent to the indifference curve

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at the optimal consumption bundle *A*. An increase in Eve's income is represented by the outward parallel shift of

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to

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Because the prices of the goods are unchanged, Eve can now afford to buy more vacations and basketball tickets, and her new utility-maximizing bundle is *B*, where indifference curve

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is tangent to

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income effect
The change in a consumer's consumption choices that results from a change in the purchasing power of the consumer's income.

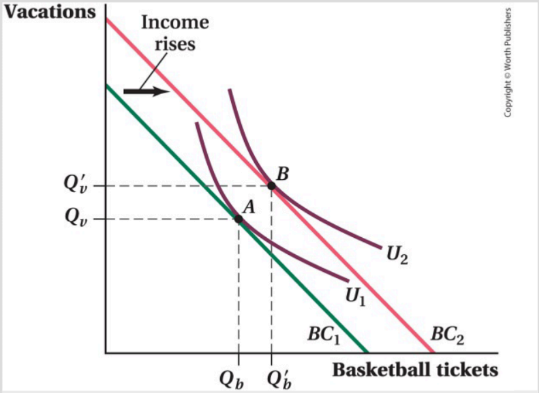

Figure 5.1 Consumer's Response to an Increase in Income When Both Goods Are Normal

Initially, Eve's budget constraint is

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and the utility-maximizing consumption bundle occurs at point *A*, where indifference curve

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is tangent to

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If the prices of vacations and basketball tickets remain unchanged, an increase in Eve's income means that she can afford more of both goods. As a result, the increase in income induces a parallel, outward shift in the budget constraint from

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to

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Note that, because we hold prices fixed, the slope of the budget constraint (the ratio of the goods' prices) remains fixed. The new optimal consumption bundle at this higher income level is *B*, the point where indifference curve

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is tangent to

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At bundle *B*, Eve's consumption of vacations and basketball tickets rises from

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to

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and

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to
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respectively.

Because
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shows bundles of goods that offer a higher utility level than those on
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the increase in income allows Eve to achieve a higher utility level. Because when we analyze the effect of changes in income on consumer behavior, we hold preferences (as well as prices) constant, indifference curve
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does not appear because of some income-driven shift in preferences.
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was always there even when Eve's income was lower. At the lower income, however, point *B* and all other bundles on
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(and any other higher indifference curves) were infeasible because she could not afford them.

Normal and Inferior Goods

Notice how the new optimal bundle in Figure 5.1 involves higher levels of consumption for both goods. This result isn't that surprising; Eve was spending money on both vacations and basketball tickets before her income rose, so we might expect that she'd spend some of her extra income on both goods. Recall from Chapter 2 that economists call a good for which consumption rises when income rises a **normal good**. For a normal good, the income effect is positive. Vacations and basketball tickets are normal goods for Eve. As "normal" suggests, most goods have positive income effects, but not all. A good for which consumption decreases when income rises is an **inferior good**. **Figure 5.2** presents an example in which one of the goods, macaroni and cheese, is inferior.

normal good
A good for which consumption rises when income rises.

inferior good
A good for which consumption decreases when income rises.

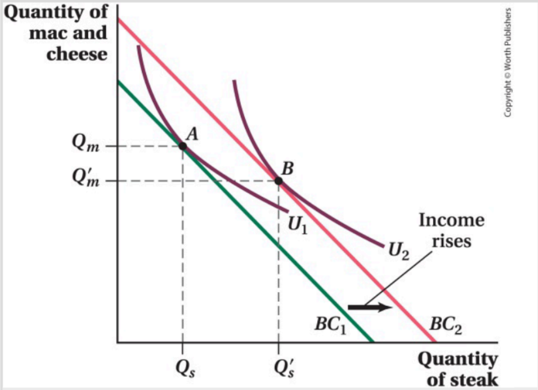

Figure 5.2 Consumer's Response to an Increase in Income When One Good Is Inferior

An increase in the consumer's income from
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to
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leads to more steak being consumed,
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml
to
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but less macaroni and cheese. Note it isn't just that the quantity of mac and cheese *relative* to the quantity of steak falls. This change can happen even when both goods are normal (i.e., they both rise, but steak rises more). Instead, it is the *absolute* quantity of macaroni and cheese consumed that drops in the move from *A* to *B*, because
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is less than
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml.
Note also that this drop is optimal from the consumer's perspective—*B* is the consumer's utility-maximizing bundle given their budget constraint
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and this bundle offers a higher utility level than *A* because indifference curve Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml represents a higher utility level than Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml.

What kinds of goods tend to be inferior? Usually, they are lower-quality or otherwise less-desirable goods. Examples might include generic cereal brands, secondhand clothing, nights spent in youth hostels, and Spam (the grocery kind, not the junk e-mail kind, which probably isn't a good at all, but rather a "bad"). We do know that *every* good can't be inferior, however, because a consumer who gets more income has to spend it on *something* (remember, there is no saving in this model).

Whether the effect of an income change on a good's consumption is positive (consumption increases) or negative (consumption decreases) can vary with the level of income. A used car, for instance, is likely to be a normal good at low levels of income, and an inferior good at high levels of income. When income is very low, owning any car beats taking the bus, so as income increases, demand for used cars goes up. For people with a very high income, used cars are supplanted by new cars and the consumption of used cars falls. At that point, used cars are an inferior good.

Income Elasticities and Types of Goods

We've discussed how the income effect can be positive (as with normal goods) or negative (as with inferior goods). We can make further distinctions between types of goods by looking not just at the sign of the income effect, but at the *income elasticity* as well, which we discussed in Chapter 2. Remember that the **income elasticity** measures the percentage change in the quantity consumed of a good in response to a given percentage change in income. Formally, the income elasticity is

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where *Q* is the quantity of the good consumed (Error parsing MathML: error on line 1 at column 670: Opening and ending tag mismatch: img line 0 and a is the change in quantity), and *I* is income (Error parsing MathML: error on line 1 at column 747: Opening and ending tag mismatch: img line 0 and a is the change in income).

income elasticity
The percentage change in the quantity consumed of a good in response to a given percentage change in income.

The first ratio in the income elasticity definition is the income effect shown in the equations above:

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the change in quantity consumed in response to a change in income. Therefore, the sign of the income elasticity is the same as the sign of the income effect. For normal goods,

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and the income elasticity is positive. For inferior goods,

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and the income elasticity is negative.

Within the class of normal goods, economists occasionally make a further distinction. The quantities of normal goods with an income elasticity between zero and 1 (sometimes called **necessity goods**) rise with income, but at a slower rate. Because prices are held constant when measuring income elasticities, the slower-than-income quantity growth implies the *share* of a consumer's budget devoted to the good *falls* as income grows. Many normal goods fit into this category, especially consumer staples that everyone needs, like toothpaste, salt, socks, and electricity. Someone earning Error parsing MathML: error on line 1 at column 850: Opening and ending tag mismatch: img line 0 and an a year may consume more of these staples than a person earning Error parsing MathML: error on line 1 at column 659: Opening and ending tag mismatch: img line 0 and an annually, but not 100 times more despite having 100 times the income.

necessity good
A normal good for which income elasticity is between zero and 1.

Luxury goods are goods with an income elasticity greater than 1. Because their quantities consumed grow faster than income does, these goods account for an increasing fraction of the consumer's expenditure as income rises. First-class airline tickets, jewelry, and vacation homes are all likely to be luxury goods.

luxury good
A good with an income elasticity greater than 1.

The Income Expansion Path

Imagine repeating the analysis in the previous section for every possible income level, starting with 0. That is, for a given set of prices and a particular set of preferences, find the utility-maximizing bundle for every possible budget constraint, where each constraint corresponds to a different income level. Those optimal bundles will be located wherever an indifference curve is tangent to a budget line. In the examples above, bundles *A* and *B* were optimal at the two income levels.

Figure 5.3 shows how Meredith allocates her income between bus rides and bottled water. Points *A, B, C, D,* and *E* are the optimal consumption bundles at five different income levels that correspond to the budget constraints shown. Note that the indifference curves themselves come from Meredith's utility function. We have chosen these indifference curve locations just to illustrate that these points can move around in different ways.

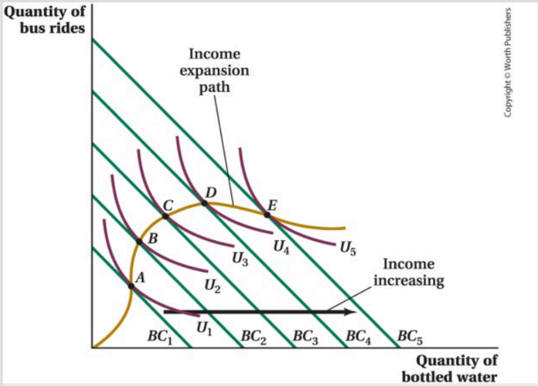

Figure 5.3 Income Expansion Path

Meredith's income expansion path connects all the optimal bundles of bottled water and bus rides for each income level. Points *A, B, C, D*, and *E* are optimal consumption bundles associated with budget constraints
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through
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Where both bottled water and bus rides are normal goods, the income expansion path is upward-sloping. At incomes higher than that shown at the budget constraint
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and to the right of bundle *D*, bus rides become inferior goods, and the income expansion path slopes downward.

If we draw a line connecting all the optimal bundles (the five here plus all the others for budget constraints we don't show in the figure), it would trace out Meredith's **income expansion path**, a curve that connects a consumer's optimal bundles at each income level. This curve always starts at the origin because when income is zero, the consumption of both goods must also be zero.

income expansion path
A curve that connects a consumer's optimal bundles at each income level.

When both goods are normal goods, the income expansion path will be positively sloped because consumption of both goods rises when income does. If the slope of the income expansion path is negative, then the quantity consumed of one of the goods falls with income while the other rises. The one whose quantity falls is an inferior good. Remember that whether a given good is normal or inferior can depend on the consumer's income level. In Figure 5.3, for example, both bus rides and bottled water are normal goods at incomes up to the level corresponding to the budget constraint containing bundle *D*. As income rises above that and the budget constraint continues to shift out, the income expansion path begins to curve downward. This outcome means that bus rides become an inferior good as Meredith's income rises beyond that level. We can also see from the income expansion path that bottled water is never inferior, because the path never curves back to the left.

The Engel Curve

The income expansion shows how consumer behavior changes in response to changes in income, but it has two important weaknesses. First, with just two axes, we can only look at two goods at a time. Second, although we can easily see the consumption quantities of each good, we can't discern the income level to which a particular point on the curve corresponds. The income level equals the sum of the quantities consumed of each good (which are easily seen in the figure) multiplied by their respective prices (which aren't listed). The basic problem is that when we talk about consumption and income, we care about three numbers—the quantities of each of the two goods and income—but we have only two dimensions on the graph through which to see them.

A better way to see how the quantity consumed of one good varies with income (as opposed to how the relative quantities of the two goods vary) is to take the information conveyed by the income expansion path and plot it on a graph with income on the vertical axis and the quantity of the good in question on the horizontal axis. Panel a of **Figure 5.4** shows the relationship between income and the quantity of bus rides from our example. The five points mapped in panel a of Figure 5.4 are the same five consumption bundles represented by points *A, B, C, D,* and *E* in Figure 5.3; the only difference between the figures is in the variables measured by the axes.

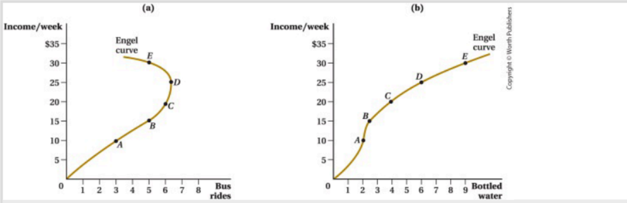

Figure 5.4 Engel Curves Show How Consumption Varies with Income

(a) In contrast to an income expansion path, an Engel curve compares the consumption of a single good to the consumer's income. As Meredith's income increases from Error parsing MathML: error on line 1 at column 816: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 816: Opening and ending tag mismatch: img line 0 and annotation-xml, her consumption of bus rides increases from 3 to a little over 6 bus rides. At income levels above Error parsing MathML: error on line 1 at column 816: Opening and ending tag mismatch: img line 0 and annotation-xml, bus rides are inferior goods, and the number of bus rides she takes decreases.

(b) Bottled water is a normal good, so positively sloped, across all income levels shown here. At an income of Error parsing MathML: error on line 1 at column 816: Opening and ending tag mismatch: img line 0 and annotation-xml at point *A*, Meredith consumes 2 bottles of water. At point *E*, Meredith's income is Error parsing MathML: error on line 1 at column 816: Opening and ending tag mismatch: img line 0 and annotation-xml, and the number of bottles of water she buys increases to 9 per week.

The lines traced out in Figure 5.4 are known as *Engel curves,* named for the nineteenth-century German economist Ernst Engel who first presented the data in this way. **Engel curves** show the relationship between the quantity of a good consumed and a consumer's income—bus rides and bottled water, in this case. If the Engel curve has a positive slope, the good is a normal good at that income level. If the Engel curve has a negative slope, the good is an inferior good at that income. In Figure 5.4a, bus rides are initially a normal good, but become inferior after bundle *D*, just as we saw in Figure 5.3. In panel b, bottled water is a normal good at all income levels and the Engel curve is always positively sloped.

Engel curve
A curve that shows the relationship between the quantity of a good consumed and a consumer's income.

Whether income expansion paths or Engel curves are more useful for understanding the effect of income on consumption choices depends on the question. If we care about how the relative quantities of the two goods change with income, the income expansion path is more useful because it shows both quantities at the same time. On the other hand, if we want to investigate the impact of income changes on the consumption of each particular good, the Engel curve is best because it isolates this relationship more clearly. The two curves contain the same information but display it in different ways due to the limitations imposed by having only two axes.

Application: Engel Curves and Restaurants

Restaurants are perhaps the most common type of business in the economy. Cities have entire blocks full of them, and all but the smallest towns have at least one or two. According to the U.S. Bureau of Economic Analysis, Americans spend about
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at eating and drinking establishments per year. That's about
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per person. Even after the disruption of the pandemic, a recent survey found almost
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of respondents either eat or get takeout from a restaurant multiple times per month, and
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do so multiple times per week.[1] People like to go out to eat, whether for variety, to socialize, or because they're lousy cooks.

While food is a basic necessity, eating it in a restaurant is not. Eating meals at home is cheaper than eating out, so when budgets are tight, we might expect people to eat more frequently at home. An increase in income should have the opposite effect as people substitute more toward eating out.

This intuition suggests that while spending on food might rise with income, spending on food in restaurants should rise faster. That's exactly what economists Mark Aguiar and Mark Bils determined in their study of how income shapes households' consumption decisions.[2] They estimated Engel curves for a number of different goods, among them food prepared at home and restaurant meals. Food prepared at home had an income elasticity of about 0.4, so a
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increase in income led to an increase in food prepared at home of
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Restaurant meals, however, had an income elasticity of 1.3. Not only is this elasticity more than 3 times as large as that for food prepared at home, it is above 1. Restaurant meals, therefore, are a luxury good. These results are consistent with what the Gallup survey found, too: Only
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of people from households with less than
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in annual income had purchased restaurant meals the previous week, while
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of those from households with more than
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in income had done so.

Aguiar and Bils weren't just concerned with how consumption changed with income across households; they also investigated the implications of those income responses over time. Their results imply, for example, that as average incomes have risen over time, spending on restaurant meals should have increased more than proportionately due to restaurant meals being a luxury good. That is, in fact, consistent with the long-run patterns in the data. The
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(Error parsing MathML: error on line 1 at column 656: Opening and ending tag mismatch: img line 0 and annotation-xml
per person) in annual restaurant spending we see today is much higher than it used to be. For example, total restaurant spending in the United States 55 years ago was only
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(adjusted for inflation to today's dollars), around one-fifth of what it is now. The population then was smaller, but not four-fifths smaller. Dividing by the population at the time suggests annual restaurant spending of
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per person, just a bit over one-third its current level.

The high income responsiveness of food consumed outside the home has led to a long-run restaurant boom as Americans have become wealthier. So, the next time you get excited about checking out some new trattoria down the street, remember that part of the reason the restaurant has opened is likely because of your and your neighbors' incomes are going up. Indeed, some people take the opening of chains like Starbucks as a leading indicator of neighborhood gentrification. ■

figure it out 5.1

Annika spends all of her income on golf and pancakes. Greens fees at a local golf course are
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per round. Pancake mix is
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per box. When Annika's income is
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per week, she buys 5 boxes of pancake mix and 9 rounds of golf. When Annika's income rises to
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per week, she buys 10 boxes of pancake mix and 10 rounds of golf. Based on these figures, determine whether each of the following statements is true or false, and briefly explain your reasoning.

a. Golf is a normal good, and pancake mix is an inferior good.
b. Golf is a luxury good.

c. Pancakes are a luxury good.

Solution:

a. A normal good is one of which a consumer buys more when income rises. An inferior good is a good for which consumption falls when income rises. When Annika’s income rises, she purchases more pancake mix and more rounds of golf. This means that both goods are normal goods for Annika. Therefore, the statement is *false*.

b. A luxury good has an income elasticity greater than 1. The income elasticity for a good is calculated by dividing the percentage change in quantity demanded by the percentage change in income. Annika’s income rises from

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to

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Therefore, the percentage change in income is

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When Annika’s income rises, her consumption of golf changes from 9 rounds to 10. Thus, the percentage change in the quantity of rounds demanded is

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To calculate the income elasticity, we divide the percentage change in quantity by the percentage change in income,

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Golf cannot be a luxury good for Annika because the income elasticity is not greater than 1. Therefore, the statement is *false*.

c. Again, we must calculate the income elasticity, this time for pancake mix. When Annika’s income rises from

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to

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[a

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rise as calculated in part (b)], Annika increases her purchases of pancake mix from 5 boxes to 10 boxes. Thus, the percentage change in the quantity of pancake mix demanded is

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This means that the income elasticity of demand is

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Because the income elasticity is greater than 1, pancake mix is a luxury good for Annika. Therefore, the statement is *true*.

5.2 How Price Changes Affect Consumption Choices

We now know how changes in income affect a consumer’s choices, holding prices and preferences constant. In this section, we see what happens when the price of a good changes, holding income, preferences, and the prices of all other goods constant. *This analysis will tell us exactly where a demand curve comes from.*

At this point, it’s useful to recall exactly what a demand curve is. We learned in Chapter 2 that although many factors influence the quantity a consumer demands of a good, the demand curve only isolates how the good’s own price affects the quantity demanded while holding everything else constant. Changes in any other factor (such as income, preferences, or the prices of other goods) *shift* the demand curve.

Up to this point, it always seemed that demand curves slope downward because diminishing marginal utility implies that consumers’ willingness to pay falls as quantities rise. That explanation is still correct as a summary, but it skips a step. A consumer’s demand curve actually comes straight from the consumer’s utility maximization. *A demand curve answers the following question: As the price of a good changes (while holding all else constant), how does the quantity of that good in the utility-maximizing bundle change?*

Deriving a Demand Curve

To see how a consumer’s utility-maximizing behavior leads to a demand curve, let’s look at a specific example. Caroline is deciding how to spend her income on two goods, 2-liter bottles of Mountain Dew and 1-liter bottles of grape juice, and we want to know her demand curve for grape juice. Caroline’s income is

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and the price of Mountain Dew is

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per 2-liter bottle. We hold these other factors (income and price of Mountain Dew) and

Caroline’s preferences constant throughout our analysis. If we didn’t, we would not be mapping out a single demand curve but would, instead, be shifting the demand curve around.

To build the demand curve, we start by figuring out the consumer’s utility-maximizing consumption bundle at some price for grape juice. We can start with any price we want. Let’s say
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per liter bottle of grape juice to make it easy.

The top half of [Figure 5.5a](#) shows Caroline’s utility-maximization problem. Her budget constraint reflects the combinations of bottles of Mountain Dew and bottles of grape juice that she can afford at the current prices. With an income of
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she can buy up to 10 bottles of Mountain Dew at
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per bottle if that’s all she spends her money on, or up to 20 bottles of grape juice at
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per bottle if she only buys grape juice. The slope of the budget constraint equals the negative of the price ratio
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which is
Error parsing MathML: error on line 1 at column 644: Opening and ending tag mismatch: img line 0 and an
in this case. The figure also shows the indifference curve that is tangent to this budget constraint. The point of tangency gives the utility-maximizing bundle. Given her income, her preferences, and the prices of the two drinks, Caroline’s optimal quantities to consume are 3 bottles of Mountain Dew and 14 bottles of grape juice.

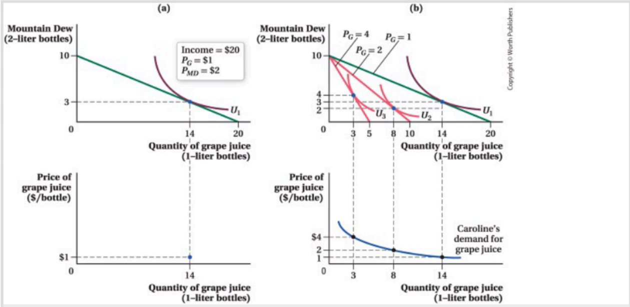

Figure 5.5 Building an Individual’s Demand Curve

(a) At her optimal consumption bundle, Caroline purchases 14 bottles of grape juice when the price per bottle is
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and her income is
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The bottom panel plots this point on her demand curve, with the price of grape juice on the *y*-axis and the quantity of grape juice on the *x*-axis.

(b) A completed demand curve consists of many of these quantity-price points. Here, the optimal quantity of grape juice consumed is plotted for the prices
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Error parsing MathML: error on line 1 at column 646: Opening and ending tag mismatch: img line 0 and annotation-xml,
and
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per bottle. This creates Caroline’s demand curve, as shown in the bottom panel.

That yields 1 point on Caroline’s demand curve for grape juice: At a price of
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per liter, her quantity demanded is 14 bottles. The only problem is that the top panel of [Figure 5.5a](#) does not have the correct axes for a demand curve. Remember that a demand curve for a good is drawn with the good’s price on the vertical axis and its quantity demanded on the horizontal axis. When we graphically search for the tangency of indifference curves and budget constraints, however, we put the quantities of the two goods on the axes. Thus, we’ll create a new figure, shown in the bottom

panel of Figure 5.5a, that plots the same quantity of grape juice as the figure's top panel, but with the price of grape juice on the vertical axis. Because the horizontal axis in the bottom panel is the same as that in the top—the quantity of grape juice—we can vertically transfer that dimension of the figure directly from the top to the bottom panel.

To finish building the demand curve, we just repeat the process for different prices of grape juice. When the price changes, the budget constraint's slope changes, which reflects the relative prices of the two goods. For each new budget constraint, we determine the optimal consumption bundle by finding the indifference curve that is tangent to it. Preferences are constant, so the set of indifference curves corresponding to Caroline's utility function remains the same. The particular indifference curve that is tangent to the budget constraint will depend on where the constraint is, however. Each time we determine the optimal quantity consumed at a given price of grape juice, we identify another point on the demand curve.

Figure 5.5b shows this exercise for grape juice prices of

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and

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per bottle. As the price of grape juice rises (holding fixed the price of Mountain Dew and Caroline's income), the budget constraint gets steeper, and the utility-maximizing quantity of grape juice falls. In our example, Caroline's optimal quantity of grape juice when it costs

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per bottle is 8 bottles. When the price is

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she consumes 3 bottles. These combinations of prices and quantities are plotted in the lower panel. These points are all on Caroline's demand curve for grape juice. Repeating this exercise for every possible grape juice price will trace out her whole demand curve, which we've drawn in the figure. Caroline's quantity demanded falls as price rises.

Shifts in the Demand Curve

We know that if a consumer's preferences or income change, or the prices of other goods change, then the demand curve shifts. We can see how by tracing out the demand curve under these new conditions.

Let's look at an example where preferences change. Suppose that Caroline's sister, who is a dietician, tells her that the purported health benefits of grape juice are overstated and that it stains your teeth red. This changes Caroline's preferences toward grape juice: She finds it less desirable. This change shows up as a flattening of Caroline's indifference curves, because now she has to be given more grape juice to be indifferent to a loss of Mountain Dew. Another way to think about this is as follows: Because the marginal rate of substitution (MRS) equals

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this preference shift shrinks Caroline's marginal utility of grape juice at any quantity, reducing her *MRS*—that is, flattening her indifference curves. **Figure 5.6** repeats the demand-curve building exercise after the preference change.

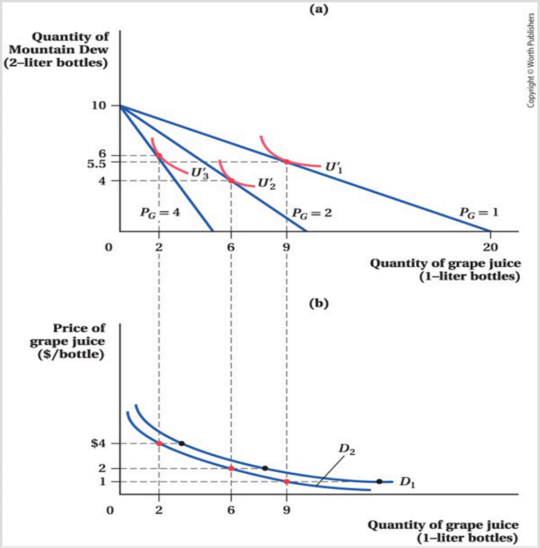

Figure 5.6 Preference Changes and Shifts in the Demand Curve

(a) With the flatter indifference curves (labeled Error parsing MathML: error on line 1 at column 786: Opening and ending tag mismatch: img line 0 and annotation-xml, Error parsing MathML: error on line 1 at column 786: Opening and ending tag mismatch: img line 0 and annotation-xml, and Error parsing MathML: error on line 1 at column 786: Opening and ending tag mismatch: img line 0 and annotation-xml), Caroline's utility-maximizing consumption bundles have changed. Now her optimal consumption levels of grape juice at prices of Error parsing MathML: error on line 1 at column 646: Opening and ending tag mismatch: img line 0 and annotation-xml, Error parsing MathML: error on line 1 at column 646: Opening and ending tag mismatch: img line 0 and annotation-xml, and Error parsing MathML: error on line 1 at column 646: Opening and ending tag mismatch: img line 0 and annotation-xml per bottle are 9, 6, and 2 bottles, respectively. At each price level, she now consumes fewer bottles of grape juice.

(b) Because she purchases fewer bottles of grape juice at each price point, Caroline's demand curve for grape juice shifts inward from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml.

Appendix 5B derives the demand curve directly from the utility function.

We can see that because Caroline's preferences have changed, she now demands a smaller quantity of grape juice than before (Figure 5.5) at every price. As a result, her demand curve for grape juice has shifted in from Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an This result demonstrates why and how preference changes shift the demand curve. Changes in Caroline's income or in the price of Mountain Dew also shift her demand curve. (We saw earlier how income shifts affect quantity demanded, and we investigate the effects of price changes in other goods in Section 5.4.) Remember, however, that for any *given* value of these factors on demand, the change in the quantity demanded of a good in response to changes in its own price results in a movement along a demand curve, not a shift in the curve.

FREAKONOMICS

Even Animals Like Sales

If you think the laws of economics only apply to humans, think again. Monkeys, and even rats, behave in ways that would make you think they've taken intermediate micro.

Some of the most intensive testing of the economic behavior of animals was carried out by economist Keith Chen and his coauthors on a group of Capuchin monkeys. As a first step, Chen introduced the monkeys to the concept of money. He gave them "money" in the form of metal washers that they could exchange for various types of foods including Jell-O, grapes, and Marshmallow Fluff (Capuchin monkeys *love* sweets).

After about six exasperating months, these monkeys finally figured out that the washers had value. Chen observed that individual monkeys tended to have stable preferences: Some liked grapes the best, others were fans of Jell-O. How did he learn this? He would give a particular monkey a coin and then offer that monkey a choice between a bowl of 3 Jell-O cubes and a bowl of 6 grapes, and see which one the monkey chose.

Next, Chen did what any good economist would do: He subjected the monkeys to price changes! Instead of getting 3 Jell-O cubes for one washer, he would offer the monkey, say, the choice between a single Jell-O cube per washer and a bowl of 6 grapes per washer. Thus, the relative price of Jell-O became 3 times as high. The monkeys responded exactly the way economic theory would predict, shifting their consumption away from the goods whose prices had risen.[*]

Perhaps it is not so surprising that monkeys, one of our closest relatives in the animal kingdom, would be sophisticated consumers. But there is no way rats understand supply and demand, is there? It seems they do. Economists Raymond Battalio and John Kagel equipped rats' cages with two levers, each of which dispensed a different beverage.[†] One of these levers gave the rat a refreshing burst of root beer. Rats, it turns out, love root beer. The other lever released quinine water. Quinine is a bitter-tasting substance initially used to treat malaria, and now used primarily to give vodka tonics their distinctive flavor. Rats are far less fond of quinine than they are of root beer, and they made that quite clear to the researchers by pressing the root beer lever far more often. Battalio and Kagel, like Chen, then explored changes in "prices" (how much liquid came out per press of the lever) and in the rats' budget constraint (how many times they could press the levers each day). Like monkeys (and humans), the rats consumed less of a drink when its relative price increased. Even more interesting is that when the rats were made very poor (i.e., allowed to press a lever only a few times per day), they shifted their consumption away from root beer toward quinine water. The researchers found that root beer is a luxury good for rats, and quinine water is an inferior good! Perhaps if the researchers had only mixed the quinine with a little bit of vodka, things would have been different. …

Yves Herman/Reuters/Alamy Stock Photo

Bargain hunters at the grape market.

figure it out 5.2

Cooper allocates
Error parsing MathML: error on line 1 at column 652: Opening and ending tag mismatch: img line 0 and annotation-xml
of his weekly budget to entertainment. He spends all of this
Error parsing MathML: error on line 1 at column 652: Opening and ending tag mismatch: img line 0 and annotation-xml
on two goods: tickets to live events at the local theater (which cost
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each) and movie tickets (which cost
Error parsing MathML: error on line 1 at column 649: Opening and ending tag mismatch: img line 0 and annotation-xml
each).

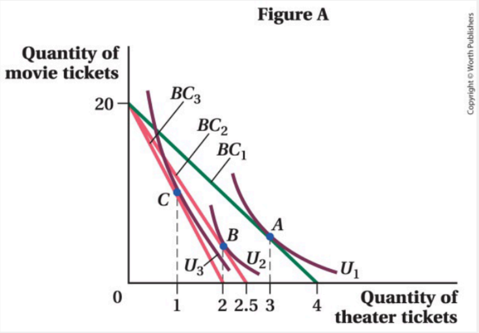
a. With theater tickets on the horizontal axis, draw Cooper's budget constraint, making sure to indicate the horizontal and vertical intercepts. What is the slope of the budget constraint?
b. Suppose that Cooper currently purchases 3 theater tickets per week. Indicate this choice on the budget constraint and mark it as point *A*. Draw an indifference curve tangent to the budget constraint at point *A*. How many movie tickets does Cooper buy?
c. Suppose that the price of a theater ticket rises to
Error parsing MathML: error on line 1 at column 649: Opening and ending tag mismatch: img line 0 and annotation-xml,
and Cooper lowers his purchases of theater tickets to 2. Draw Cooper's new budget constraint, indicate his choice with a point *B*, and draw an indifference curve tangent to the new budget constraint at point *B*.

d. Once again, the price of a theater ticket rises to Error parsing MathML: error on line 1 at column 652: Opening and ending tag mismatch: img line 0 and annotation-xml, and Cooper lowers his purchases of theater tickets to 1 per week. Draw his new budget constraint, show his choice on the budget constraint with a point *C*, and draw an indifference curve tangent to this new budget constraint at *C*.

e. Draw a new diagram below your indifference curve diagram. Use your answers to parts (b)–(d) to draw Cooper's demand for theater tickets. Indicate his quantities demanded at Error parsing MathML: error on line 1 at column 649: Opening and ending tag mismatch: img line 0 and annotation-xml, Error parsing MathML: error on line 1 at column 649: Opening and ending tag mismatch: img line 0 and annotation-xml, and Error parsing MathML: error on line 1 at column 652: Opening and ending tag mismatch: img line 0 and annotation-xml. Is there an inverse relationship between price and quantity demanded?

Solution:

a. To start, we need to calculate the horizontal and vertical intercepts for Cooper's budget constraint. The horizontal intercept is the point at which Cooper spends all his income on theater tickets and purchases no movie tickets. This occurs when he buys. Error parsing MathML: error on line 1 at column 970: Opening and ending tag mismatch: img line 0 and annotation-xml theater tickets (Figure A). The vertical intercept is the point at which Cooper spends his entire income on movie tickets and buys no theater tickets. This means that he is buying Error parsing MathML: error on line 1 at column 973: Opening and ending tag mismatch: img line 0 and annotation-xml movie tickets. The budget constraint connects these two intercepts. The slope of the budget constraint equals Error parsing MathML: error on line 1 at column 1141: Opening and ending tag mismatch: img line 0 and annotation-xml.



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Note that this slope is the negative of the ratio of the two prices:

Error parsing MathML: error on line 1 at column 2362: Opening and ending tag mismatch: img line 0 and annotation-xml.

b. Maximum utility occurs where the indifference curve is tangent to the budget constraint. Therefore, point *A* should be the point where this tangency takes place. If Cooper purchases 3 theater tickets a week, he will spend Error parsing MathML: error on line 1 at column 972: Opening and ending tag mismatch: img line 0 and annotation-xml, leaving him Error parsing MathML: error on line 1 at column 1041: Opening and ending tag mismatch: img line 0 and annotation-xml to spend on movie tickets. Since movie tickets cost Error parsing MathML: error on line 1 at column 649: Opening and ending tag mismatch: img line 0 and annotation-xml each, he purchases Error parsing MathML: error on line 1 at column 967: Opening and ending tag mismatch: img line 0 and annotation-xml movie tickets.

c. Cooper's budget constraint will rotate in a clockwise direction. The vertical intercept is not affected because neither Cooper's income nor the price of movie tickets changes. However, the price of theater tickets has risen to Error parsing MathML: error on line 1 at column 649: Opening and ending tag mismatch: img line 0 and annotation-xml, and now if Cooper were to allocate his entire budget to theater tickets, he could afford only Error parsing MathML: error on line 1 at column 976: Opening and ending tag mismatch: img line 0 and annotation-xml of them. This is the new horizontal intercept. If Cooper chooses to buy 2 theater tickets, he will have an indifference curve tangent to this budget constraint at that point (*B*).

d. The budget constraint will again rotate clockwise and the vertical intercept will remain unchanged. The new horizontal intercept will be Error parsing MathML: error on line 1 at column 973: Opening and ending tag mismatch: img line 0 and annotation-xml. Point *C* will occur where Cooper's indifference curve is tangent to his new budget constraint at a quantity of 1 theater ticket.

e. The demand curve shows the relationship between the price of theater tickets and Cooper's quantity demanded. We can take the information from our indifference curve diagram to develop three points on Cooper's demand curve:

Point	Price
A	Error parsing MathML: error on line 9 at column 44: Opening and ending tag mismatch: im
B	Error parsing MathML: error on line 9 at column 44: Opening and ending tag mismatch: im
C	Error parsing MathML: error on line 9 at column 44: Opening and ending tag mismatch: im

We can then plot points *A*, *B*, and *C* on a diagram with the quantity of theater tickets on the horizontal axis and the price of theater tickets on the vertical axis (Figure B). Connecting these points gives us Cooper's demand curve for theater tickets.

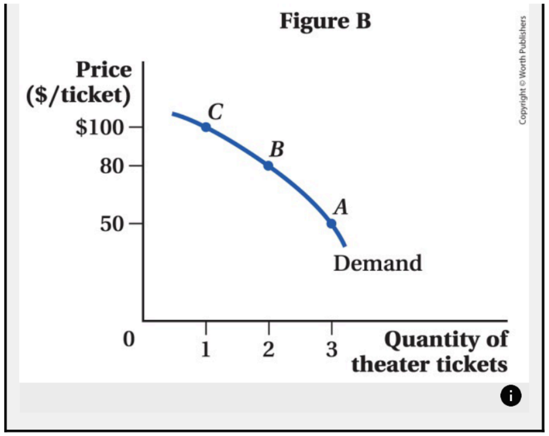
Figure B

5.3 Consumer Responses to Price Changes: Substitution and Income Effects

When the price of a good changes, the demand curve tells us how much consumption will change. That total change in quantity demanded, however, is a result of two distinct forces that affect consumers' decisions:

1. The substitution effect is the change in a consumer's consumption choices that results from a change in the relative prices of two goods—consumers wanting to buy more of the good that has become relatively cheaper and less of the relatively more expensive one.
2. The income effect is the change in a consumer's consumption choices that results from a change in the purchasing power of the consumer's income. A price shift changes the purchasing power of consumers' incomes—the amount of goods they can buy with a given dollar-level expenditure. If a good gets cheaper, for example, consumers are effectively richer and can buy more of the cheaper good and other goods. If a good's price increases, the purchasing power of consumers' incomes is reduced, and they can buy fewer goods.

substitution effect
The change in a consumer's consumption choices that results from a change in the relative prices of two goods.

The distinction between substitution and income effects is one of the most subtle concepts that you will come across in this entire book. Two factors make this topic difficult. First, we never observe these two effects separately in the real world, only their combined effects. As a consumer, you figure out how much to consume without knowing or determining how much of the change is due to income effects and how much is due to substitution effects. Separating the effects out is an artificial analytical tool—but it is useful. Second, the income effect occurs even when the consumer's *measured* income remains constant. If your income stays at
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
but the prices of all goods fall by half, you just doubled your income even though your measured income remained the same. The income effect refers to how rich you are in

terms of purchasing power, not the number of dollar bills in your pocket.

In our overview, we demonstrate income and substitution effects using graphs. Appendix 5A, located at the end of this chapter, describes these effects mathematically.

Figure 5.7 shows how one consumer, Carlos, who spends his income on attending music concerts and basketball games, reacts to a fall in the price of basketball tickets. This is just like the analysis we did in Section 5.2.

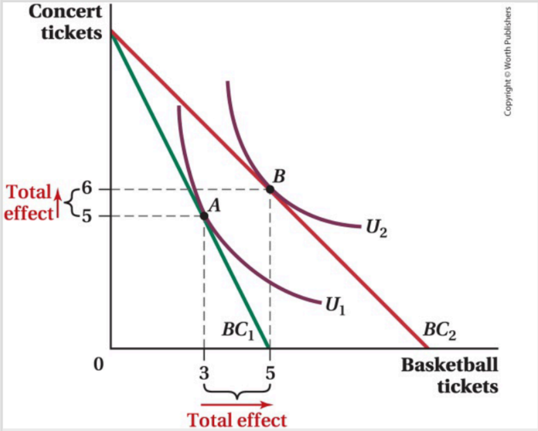

Figure 5.7 Effects of a Fall in the Price of Basketball Tickets

When the price of basketball game tickets decreases, Carlos's budget constraint rotates outward from
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to
Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and annotation-xml
because Carlos can now purchase more basketball tickets with his income. As a result, the optimal consumption bundle shifts from *A* (the point of tangency between indifference curve
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and budget constraint
Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and annotation-xml)

to *B* (the point of tangency between indifference curve
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml
and budget constraint
Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and annotation-xml).
Because of the fall in the price of basketball tickets, the quantity of concert tickets consumed increases from 5 to 6, and the number of basketball tickets Carlos purchases rises from 3 to 5.

Note that just as in Section 5.2, we figured out the optimal bundle without any reference to income or substitution effects. These overall changes in quantities consumed between bundles *A* and *B* are the **total effect**, the total change in a consumer's optimal consumption bundle as a result of a price change. In the next sections, we break down the *total effect* into separate *substitution* and *income effects*. That is,

Error parsing MathML: error on line 12 at column 30: Opening and ending tag mismatch: img line 0 and ar

total effect
The total change
Error parsing MathML: error on line 1 at column 1165: Opening and ending tag mismatch: img line 0 and annotation-xml effect in a consumer's optimal consumption bundle as a result of a price change.

Breaking down the movement from *A* to *B* into income and substitution effects helps us understand how much of the total change in Carlos's quantity demanded occurs because Carlos switches what he purchases as a result of the reduction in the relative prices of the two goods (the substitution effect), and how much of the change is driven by the fact that the decrease in the price of basketball tickets gives Carlos more purchasing power (the income effect).

Note also that all the examples we work through involve a drop in the price of a good. When the price of a good increases, the effects work the same but in the opposite direction.

Isolating the Substitution Effect

Let's begin by isolating the substitution effect. This part of the change in quantities demanded is due only to the change in relative prices, not to the change in Carlos's buying power. To isolate the substitution effect, we need to figure out how many concert and basketball tickets Carlos would want to buy if, after the price change, there was no income effect—that is, if he had the same purchasing power as before the price change and felt neither richer nor poorer.

For Carlos to feel neither richer nor poorer, the *bundle he consumes after the price change must provide him with the same utility he was receiving before the price change; that is, the new bundle must be on the initial indifference curve*
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an

The substitution-effect-only bundle on
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
has to reflect the fact that the goods' relative prices have changed. Those new relative prices are seen in the slope of the new budget line
Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and an
The problem is that a point of tangency doesn't exist between
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
and
Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and an
—as we can see in **Figure 5.8**. However, there *is* a point of tangency between
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
and a budget line with the same slope (i.e., the same relative prices) as
Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and an
The budget line we're talking about is
Error parsing MathML: error on line 1 at column 768: Opening and ending tag mismatch: img line 0 and an
the dashed line in Figure 5.8a, and the point of tangency is point
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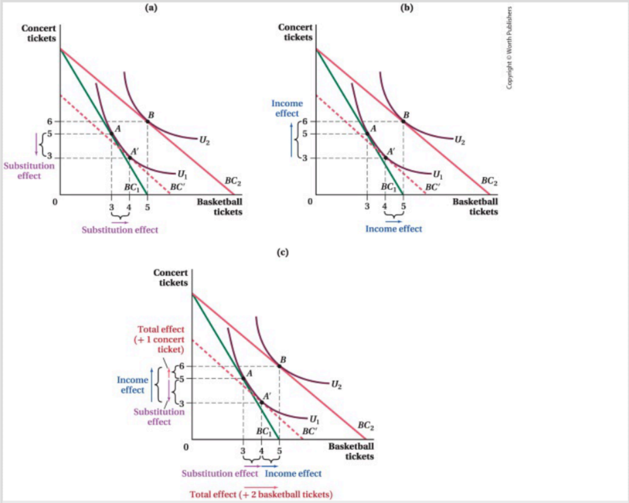


Figure 5.8 Substitution and Income Effects for Two Normal Goods

(a) The substitution effect is the change in quantities demanded due to the change in relative prices of basketball and concert tickets after the price of basketball tickets decreases. The budget constraint
Error parsing MathML: error on line 1 at column 768: Opening and ending tag mismatch: img line 0 and annotation-xml is parallel to Carlos's new budget constraint
Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and annotation-xml
but tangent to his original utility level
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml.
The point of tangency between
Error parsing MathML: error on line 1 at column 768: Opening and ending tag mismatch: img line 0 and annotation-xml
and
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml,
consumption bundle
Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and annotation-xml, is
the bundle Carlos would purchase if relative prices changed but his purchasing power did not. *The change from bundle A to bundle*
Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and annotation-xml
along the initial indifference curve is the substitution effect.

(b) The income effect is the change in quantities demanded due to the change in the consumer's purchasing power after the change in prices. When the price of basketball tickets decreases, Carlos can afford to purchase a larger bundle than he could before the price change. The change in the quantity of goods consumed from bundle Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and annotation-xml to *B* represents the income effect.

(c) The total effect is the sum of the substitution and income effects. In this case, Carlos buys 1 more concert ticket and 2 more basketball tickets.

Bundle Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and an is what Carlos would buy if the relative prices of concert and basketball tickets changed the same way, but Carlos experienced no change in purchasing power. This is the definition of the substitution effect. Thus, the substitution effect, in isolation, moves Carlos's demanded bundle from A to Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and an To find this effect, we have to shift the post-price-change budget line Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and an back in parallel (to preserve the new relative prices) until it is tangent to the pre-price-change indifference curve Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an (to keep the original utility level the same). To isolate the substitution effect when a price falls, we need Carlos's income to fall a little bit to erase how much richer he feels because the new lower price increases his effective purchasing power. *It's important to recognize that the budget line is hypothetical—Carlos never actually faces it.* Instead, it is a conceptual device that lets us figure out what Carlos would do *if* he faced it; that is, if relative prices changed in the way they actually did while he, at the same time, lost the small income gains he enjoyed from the price cut.

There are a few things to notice about the change in quantities due to the substitution effect. First, the quantity of concert tickets decreases (from 5 to 3), and the quantity of basketball tickets increases (from 3 to 4). The decrease in the quantity of concert tickets demanded occurs because the price change has caused basketball tickets to become cheaper relative to concert tickets, so Carlos wants to buy relatively more basketball tickets. Second, while points A and Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and an are on the same indifference curve (and Carlos therefore gets the same utility from either bundle), it costs Carlos less to buy bundle Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and an at the new prices than to buy A. We know this because point A is located above Error parsing MathML: error on line 1 at column 768: Opening and ending tag mismatch: img line 0 and an and so is infeasible if the budget constraint is Error parsing MathML: error on line 1 at column 768: Opening and ending tag mismatch: img line 0 and an (Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and a however, being on Error parsing MathML: error on line 1 at column 768: Opening and ending tag mismatch: img line 0 and an is feasible with this constraint.)

Carlos therefore responds to the decline in basketball ticket prices by substituting away from concert tickets and toward basketball tickets. By moving down along Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an Carlos has effectively made himself better off; he is getting the same utility (he's still on Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an for less money (bundle A is no longer feasible even though Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and an is).

Isolating the Income Effect

Appendix 5A, located at the end of this chapter, uses calculus to decompose the total effect of a price change into substitution and income effects.

The income effect is the part of the total change in quantities consumed that is due to

the change in Carlos's buying power after the price change. It seems a little strange that there is an income effect even though only the price of a good changed, not the actual income Carlos had to spend. But notice that when the price of a good falls, Carlos becomes richer overall because, unlike before, he now has some money left over. The reduction in a good's price means there's a whole new set of bundles Carlos can now buy that he couldn't afford before. In a sense, that money left over is the increase in his income from the price change. At the old prices, everything above and to the right of
Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and an
was infeasible; at the new prices, only bundles outside
Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and an
are infeasible (Figure 5.8b).

This increase in buying power allows Carlos to achieve a higher level of utility than he did before. The income effect is the change in Carlos's choices driven by this shift in buying power while holding relative prices fixed at their new level. Finding these income-effect consumption changes is easy once we've isolated the substitution effect. Remember that to find bundle
Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and an
we shifted the new budget constraint back in parallel until it was tangent to the original indifference curve. Doing that shift in reverse reflects the income effect exactly: It is the shift in consumption quantities (from bundle
Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and an
to *B* in Figure 5.8b) due to Carlos's ability to reach a higher indifference curve
(Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
instead of
Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and an
while holding relative prices fixed
(Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and an
and
Error parsing MathML: error on line 1 at column 768: Opening and ending tag mismatch: img line 0 and an
have the same slope).

In this particular example, the income effect led to increases in the quantities of both concert and basketball tickets. That means both goods are normal goods. In the next section, we offer an example in which one of the goods is inferior.

make the grade

Computing substitution and income effects from a price change

There are three basic steps to analyzing substitution and income effects. We start with the consumer at a point of maximum utility (point *A*) where their indifference curve is tangent to their budget constraint.

1. When prices change, draw the new budget constraint (a price change rotates the budget constraint, altering its slope). Then find the optimal quantity at the point (point *B*) where this new budget constraint is tangent to a new indifference curve.
2. Draw a new line that is parallel to the new budget constraint from Step 1 and tangent to the original indifference curve at point
Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and annotation-xml.
The movement along the original indifference curve from point *A* (the original, pre-price-change bundle) to this new tangency (point
Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and annotation-xml)
is the substitution effect. This movement shows how quantities change when relative prices change, even when the purchasing power of income is constant.
3. The income effect of the price change is seen in the movement from point
Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and annotation-xml
on the initial indifference curve to point *B* on the indifference curve at the new price. Here, relative prices are held constant (the budget lines are parallel) but the purchasing power of income changes.

The Total Effects

Figure 5.8c shows the total effects of the decline in basketball ticket prices:

1. The quantity of concert tickets Carlos desires rises by 1 ticket from 5 in the initial bundle at point *A* to 6 in the final bundle at point *B*. (A decline of 2 caused by the substitution effect is counteracted by a rise of 3 caused by the income effect for a net gain of 1 concert ticket.)
2. The quantity of basketball tickets Carlos wants to buy rises by 2, from 3 in the initial bundle *A* to 5 in the final bundle *B*. (This is a rise of 1 caused by the substitution effect plus a rise of 1 caused by the income effect.)

What Determines the Size of the Substitution and Income Effects?

The size (and as we'll see shortly, sometimes the direction) of the total effect of a price change depends on the relative sizes of its substitution and income effects. So, it's important to understand what factors influence how large substitution and income effects are. We discuss some of the more important factors below.

The Size of the Substitution Effect

The size of the substitution effect depends on the degree of curvature of the indifference curves. You can see this in Figure 5.9. The figure's two panels show the substitution effects of the same change in the relative prices of concert and basketball tickets for two different indifference curve shapes. (We know it's the same relative price change because the budget constraints' slope changes by the same amount in both panels.) When indifference curves are highly curved, as in Figure 5.9a, the MRS changes quickly as one moves along them. This means any given price change won't alter consumption choices much, because one doesn't need to move far along the indifference curve to change the MRS to match the new relative prices. Thus, the substitution effect is small. This is unsurprising, because we learned in Chapter 4 that indifference curves have more curvature when two goods are not highly substitutable (yes, it seems kind of redundant to explain that goods have smaller substitution effects the worse substitutes they are, but there you have it).

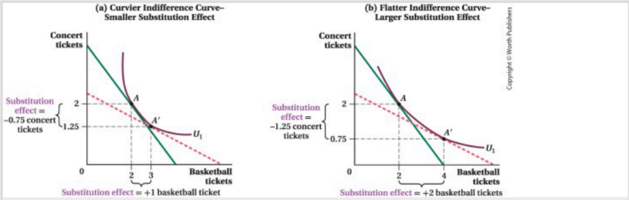


Figure 5.9 The Shape of Indifference Curves Determines the Size of the Substitution Effect

(a) When the indifference curve is highly curved, the MRS changes quickly along the curve. Thus, any given price change will not change consumption choices by much. Here, the original consumption bundle *A* is 2 basketball tickets and 2 concert tickets. After a change in prices, the new optimal consumption bundle is Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and annotation-xml, and Carlos now demands 1.25 concert tickets and 3 basketball tickets.

(b) When the indifference curve is less curved, the MRS does not change quickly along the curve. Thus, any given price change affects consumption choices more strongly. At the new optimal consumption bundle Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and annotation-xml, Carlos now demands 0.75 concert tickets and 4 basketball tickets.

When indifference curves are less curved, as in Figure 5.9b, the MRS doesn't change much along the curve, so the same relative price change causes a much greater substitution effect. The substitution from *A* to Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and an in panel b involves much larger changes in basketball and concert ticket consumption than that caused by the same relative price change in panel a.[3] Again, we can relate this to what we learned about the curvature of indifference curves in Chapter 4. Indifference curves with little curvature indicate that the two goods are close substitutes. Thus, it makes sense that a price change will lead to a much greater adjustment in the quantities in the consumer's preferred bundle.

The Size of the Income Effect

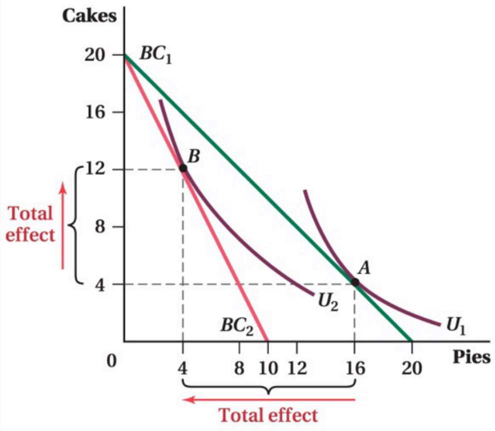
The size of the income effect is related to the quantity of each good the consumer purchases before the price change. The more the consumer was spending on the good before the price change, the greater the fraction of the consumer's budget affected by the price change. The price drop of a good that the consumer initially buys a lot of will leave him with more income left over than the price drop of a good with a smaller budget share (and a price increase will sap a greater share of the consumer's income). For example, think of how a change in the prices of food and pest control affect a typical homeowner. A typical consumer spends a larger proportion of their budget on food than on pest control. Therefore, a change in the price of food will affect the consumer's income and alter their purchases by more than a similar change in the price of pest control. (At the extreme, if the consumer currently purchases no pest control, a change in the price of pest control will have no effect on income at all.)

figure it out 5.3

Pavlo eats cakes and pies. His income is Error parsing MathML: error on line 1 at column 649: Opening and ending tag mismatch: img line 0 and annotation-xml, and when cakes and pies both cost Error parsing MathML: error on line 1 at column 646: Opening and ending tag mismatch: img line 0 and annotation-xml, Pavlo consumes 4 cakes and 16 pies (point *A* in Figure A). But when the price of pies rises to Error parsing MathML: error on line 1 at column 646: Opening and ending tag mismatch: img line 0 and annotation-xml, Pavlo consumes 12 cakes and 4 pies (point *B*).

a. Why does the budget constraint rotate as it does in response to the increase in the price of pies?
b. Trace the diagram on a piece of paper. On your diagram, separate the change in the consumption of pies into the substitution effect and the income effect. Which is larger?
c. Are pies a normal or inferior good? How do you know? Are cakes a normal or inferior good? How do you know?

Figure A



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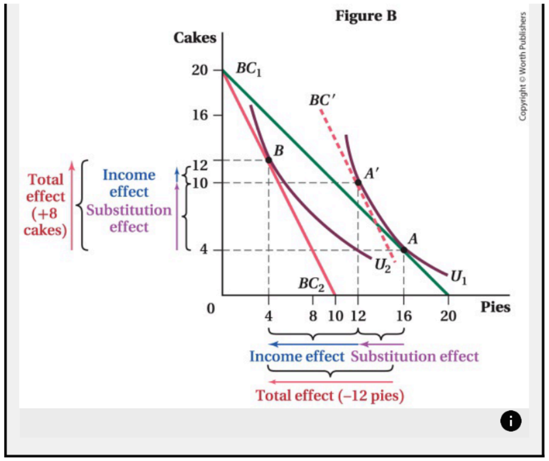
Solution:

a. The price of cakes hasn't changed, so Pavlo can still buy 20 cakes if he spends his Error parsing MathML: error on line 1 at column 649: Opening and ending tag mismatch: img line 0 and annotation-xml all on cakes (the *y*-intercept). However, at Error parsing MathML: error on line 1 at column 646: Opening and ending tag mismatch: img line 0 and annotation-xml per pie, Pavlo can now afford to buy only 10 pies instead of 20.
b. The substitution effect is measured by changing the ratio of the prices of the goods but holding utility constant (Figure B). Therefore, it must be measured along one indifference curve. To determine the substitution effect of a price change in pies, you need to shift out the post-price-change budget constraint Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and annotation-xml until it is tangent to Pavlo's initial indifference curve Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml. The easiest way to do this is to draw a new budget line Error parsing MathML: error on line 1 at column 768: Opening and ending tag mismatch: img line 0 and annotation-xml that is parallel to the new budget constraint (thus changing the ratio of the cake and pie prices) but tangent to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml (thus holding utility constant). Label the point of tangency Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and annotation-xml. Point Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and annotation-xml is the bundle Pavlo would buy if the relative prices of cakes and pies changed as they did, but he experienced no change in purchasing power. When the price of pies rises, Pavlo would substitute away from buying pies and purchase more cakes.

  The income effect is the part of the total change in quantities consumed that is due to the change in Pavlo's buying power after the price of pies changes. This is reflected in the shift from point Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and annotation-xml on budget constraint Error parsing MathML: error on line 1 at column 768: Opening and ending tag mismatch: img line 0 and annotation-xml to point *B* on budget constraint Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and annotation-xml. (These budget constraints are parallel because the income effect is measured holding relative prices constant.)

  For pies, the income effect is larger than the substitution effect. The substitution effect leads Pavlo to purchase 4 fewer pies (from 16 to 12), while the income effect further reduces his consumption by 8 pies (from 12 to 4).
c. Pies are a normal good because Pavlo purchases fewer pies (4 instead of 12) when the purchasing power of his income falls due to the price increase. However, cakes are an inferior good because the fall in purchasing power actually leads to a rise in cake consumption from 10 to 12.



An Example of the Income and Substitution Effects with an Inferior Good

Figure 5.10 provides another example of breaking out quantity changes into income and substitution effects. Here, however, one of the goods is inferior. The graph shows Judy's utility-maximizing bundles of steak and instant ramen for two sets of prices.

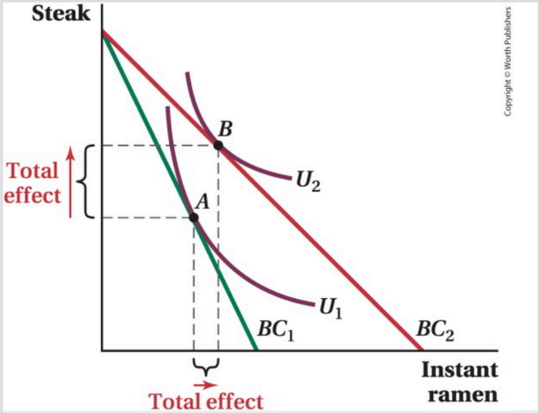


Figure 5.10 Fall in the Price of an Inferior Good

The optimal bundle at the original prices is shown at point *A*. When the price of instant ramen drops, Judy's budget constraint rotates outward from

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to

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The total effect of this price change is represented by the increase in quantities consumed from the original utility-maximizing bundle *A* to bundle *B*. Overall, Judy can reach a higher level of utility

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and her consumption of both instant ramen and steak increases.

To split the shift from bundle *A* to bundle *B* into its substitution and income effects, we follow the steps described in the previous section. To find the substitution effect, we shift the budget constraint inward from the price change until it is tangent to the original indifference curve

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This is shown by the dashed line

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in **Figure 5.11a**.

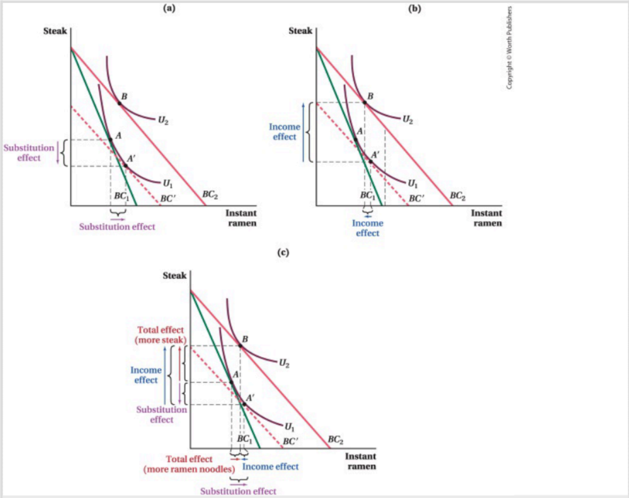

Figure 5.11 Substitution and Income Effects for an Inferior Good

(a) Error parsing MathML: error on line 1 at column 768: Opening and ending tag mismatch: img line 0 and annotation-xml is the budget constraint parallel to Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and annotation-xml, the budget constraint after the price change, and tangent to Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml, the consumer's utility before the price change. The point of tangency between Error parsing MathML: error on line 1 at column 768: Opening and ending tag mismatch: img line 0 and annotation-xml and Error parsing MathML: error on line 1 at column 695: Opening and ending tag mismatch: img line 0 and annotation-xml, consumption bundle Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and annotation-xml, is the bundle Judy would purchase if relative prices changed but her purchasing power did not. The change from bundle *A* to bundle Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and annotation-xml is the substitution effect. As before, the substitution effect leads Judy to purchase more of the good that has become relatively cheaper (instant ramen) and less of the other good (steak).

(b) The change in the quantity of goods consumed from bundle Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and annotation-xml to *B* represents the income effect. Because instant ramen is an inferior good, the income effect leads Judy to decrease her consumption of instant ramen, while her consumption of steak still increases.

(c) The change in the quantity of goods consumed from bundle *A* to *B* represents the total effect. Since the substitution effect increases the quantity demanded by more than the income effect decreases it, Judy consumes more instant ramen in the new optimal bundle *B* than in the original optimal bundle *A*.

The quantity shifts between bundle Error parsing MathML: error on line 1 at column 715: Opening and ending tag mismatch: img line 0 and an and bundle *B*, shown in **Figure 5.11b**, are due to the income effect. As before, this is the change in quantities consumed due to the shift in the budget lines from Error parsing MathML: error on line 1 at column 768: Opening and ending tag mismatch: img line 0 and an to Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and an Judy's increase in buying power while holding relative prices constant. Notice that now the income effect here reduces the quantity of instant ramen consumed, even though the drop in their price makes Judy richer by expanding the set of bundles she can consume. This just means instant ramen is an inferior good over this income range; an increase in income makes Judy want less of it.

The fact that a price drop leads to a reduction in the quantity consumed due to the income effect does not mean that the demand curve for instant ramen slopes up, because the substitution effect increases the quantity demanded by more than the income effect decreases it. Thus, the quantity of instant ramen demanded still rises when their price falls even though instant ramen is an inferior good. We see this outcome in Figure 5.11c because the total effect on the quantity of instant ramen is still positive: The optimal bundle after instant ramen becomes cheaper (bundle *B*) has a higher quantity of ramen than the optimal bundle before their price fell (bundle *A*). As a result, the demand curve for instant ramen slopes down. This is generally the case for inferior goods in the economy—while the income effect will make people want to consume less of them as their price falls, the substitution effect has a larger impact in the opposite direction, leading to a net increase in their consumption.

Theoretically, if the income effect is large enough, a reduction in the price of an inferior good could actually lead to a net decrease in its consumption. A good that exhibits this trait is called a Giffen good.

Giffen Goods

Giffen goods are goods for which a fall in price leads the consumer to demand less of the good. (They are named after British economist and statistician Sir Robert Giffen.) That is, an inverse relationship does not exist between price and quantity demanded and the demand curves of Giffen goods slope up! The more expensive a Giffen good is, the higher the quantity demanded. This happens because, for Giffen goods, the substitution effect of a price drop, which acts to increase the quantity a consumer demands of the good, is smaller than the reduction in the desired quantity caused by the income effect. Note that this means Giffen goods must be inferior goods.

Giffen good
A good for which a fall in price leads the consumer to demand less of the good.

Figure 5.12 gives a graphical example. The two goods are potatoes and meat, and potatoes are the Giffen good.

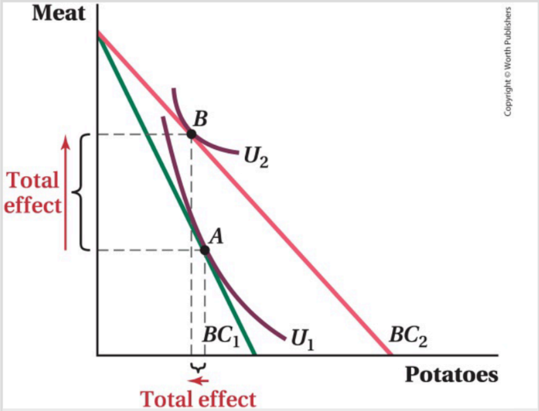

Figure 5.12 Change in the Price of a Giffen Good

When the price of a Giffen good falls, the consumer consumes less of that good. Here, the utility-maximizing bundle at the original prices is shown at point *A*. When potatoes become cheaper, the budget constraint rotates out from

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to

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and the optimal bundle shifts from *A* to *B*. Notice that in this case, when the price of potatoes decreases, the consumer purchases fewer potatoes, as reflected in the change in quantities consumed from bundle *A* to bundle *B*.

Appendix 5B takes a deeper look into income and substitution effects using the Slutsky equation.

Giffen goods are extremely rare because they need to have limited substitutability with other goods (small substitution effects with highly curved indifference curves) while also having a large income effect. Large income effects generally occur when a good accounts for a large fraction of a consumer's budget. If the price of the good falls because the consumer is already spending most of their income on it, that consumer is likely to feel a larger bump in effective buying power than if the good were only a small share of their budget. Finding goods that are a huge share of the budget but do not have many substitutes is extremely rare.

Application: A Giffen Good Is Hard to Find

While Giffen goods are theoretically possible, like Bigfoot, they are extremely rare and typically disproven on further examination. For example, for many decades, economists pointed to the potato in Ireland during the Irish famine of the mid-1800s as an example of a Giffen good. The story is that the famine-driven increase in potato prices drastically reduced the purchasing power of Irish families' incomes, shrinking the bundles of goods that they could afford because potatoes already consumed a very large fraction of a typical Irish family's meager cash income. Economists theorized that the resulting income effect led to a decrease in the demand for other foods, such as meat, that were normal goods for Irish families and an increase in the demand for potatoes, an inferior good, that swamped any substitution effect. However, when economists Gerald Dwyer and Cotton Lindsay, and later Sherwin Rosen in a separate study, examined data on the potato famine, they found that even this canonical example proved not to be a Giffen good.[4]

For one thing, if potatoes were a Giffen good for individual households, then the total market demand curve for potatoes in Ireland should have also sloped up (quantity demanded would have increased as price increased) during the famine. (We will learn about how individuals' demand curves add up to total market demand later in this chapter.) But that would mean the huge drop in supply due to the blight—about which there is no historical argument—should have led to lower potato prices. It didn't; the data show that when potatoes were available, they were sold at historically unprecedentedly high prices.

However, a recent policy experiment with extremely poor households in rural areas of China's Hunan province by Robert Jensen and Nolan Miller has produced what could be the most convincing documentation of a Giffen good to date.[5] Jensen and Miller subsidized the purchases of rice to a randomly selected set of such households, effectively lowering the price of rice that those households faced. Jensen and Miller then compared the change in rice consumption in the subsidized households to rice consumption in unsubsidized households of similar incomes and sizes.

Jensen and Miller found that the subsidy, even though it made rice cheaper, actually caused the households' rice consumption to fall. Rice was a Giffen good for these households. Rice purchases took up so much of these households' incomes that the subsidy greatly increased the households' effective buying power. (Jensen and Miller conducted a similar experiment subsidizing wheat purchases in Gansu province and also found evidence that wheat was a Giffen good for some families, though the effect was weaker.) The resulting income effect made them want to consume less rice in place of other foods for the sake of dietary variety. This income effect was large enough to outweigh the substitution effect. To oversimplify things a little, the households were initially buying enough rice to meet their caloric needs and spending their (nonexistent) leftover income on foods that added variety. When they could meet their caloric needs more cheaply, they used the now-freed-up income to buy a variety of other foods—enough to replace some of the calories formerly supplied by rice.

Interestingly, Jensen and Miller also determined that while rice was a Giffen good for very poor households, it was not a Giffen good for the very poorest of the poor. Those extremely impoverished households basically ate only rice before the subsidy, and not really enough to meet their basic caloric needs at that. When rice became cheaper, they bought more in order to meet some basic level of healthy subsistence. Essentially, even the subsidy didn't raise their income enough to allow them to buy any other foods besides rice. ■

5.4 The Impact of Changes in Another Good's Price: Substitutes and Complements

The two preceding sections showed how a change in the price of a good leads to a change in the quantity demanded of that same good. In this section, we look at the effects of a change in the price of one good on the quantity demanded of *other* goods.

To examine what happens when the price of another good changes, we start, as before, with a fixed level of income, a set of indifference curves representing the consumer's preferences, and initial prices for the two goods. We compute the optimal consumption bundle under those conditions. Then, we vary one of the prices, holding everything else constant. The only difference is that as we vary that price, we focus on how the quantity demanded of the other good changes.

A Change in the Price of a Substitute Good

Figure 5.13 shows an example of the effects of a change in the price of a substitute good—in this case, Pepsi and Coke. As we learned in Chapter 2, when the quantity demanded of one good (Coke) rises with the price of another good (Pepsi), the goods are **substitutes**, goods that can be used in place of one another. More generally, the quantity a consumer demands of a good moves in the same direction as the prices of its substitutes. The more alike two goods are, the more one can be substituted for the other, and the more responsive the increase in quantity demanded of one will be to price increases in the other. Pepsi and Coke are closer substitutes than milk and Coke.

substitute
A good that can be used in place of another good.

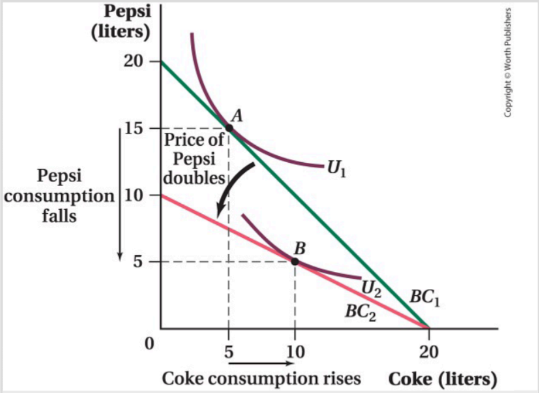

Figure 5.13 When the Price of a Substitute Rises, Demand Rises

At the original prices, the consumer consumes 15 liters of Pepsi and 5 liters of Coke at the utility-maximizing bundle *A*. When the price of Pepsi doubles, the consumer can only afford a maximum of 10 liters instead of 20 and the consumer's budget constraint rotates inward from
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to
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The maximum quantity of Coke the consumer can buy stays at 20 because the price of Coke has not changed. At the new optimal consumption bundle *B*, the consumer decreases their consumption of Pepsi from 15 to 5 liters and increases their consumption of Coke from 5 to 10 liters. Since the quantity of Coke demanded rose while the price of Pepsi rose, Coke and Pepsi are considered substitutes.

Changes in the prices of a good's substitutes lead to shifts in the good's demand curve. When a substitute for a good becomes more expensive, this raises the quantity demanded of that good at any given price level. As a result, the demand curve for the good shifts out (the demand for that good increases). When a good's substitutes become cheaper, the quantity demanded at any given price falls, and the good's demand curve shifts in.

When the quantity consumed of a good moves in the opposite direction of another good's price, they are **complements**, goods that are purchased and used in combination with another good. Complements are often goods that the consumer would use in tandem, like vanilla ice cream and hot fudge. Figure 5.14 shows how an increase in the price of ice cream leads to a decrease in the quantity demanded of hot fudge. If the price of a complement of a good increases, the quantity demanded of that good at every price decreases, and its demand curve shifts in. If the price of a complement of a good falls, the quantity demanded of that good rises at all prices and the demand curve shifts out. Changes in the price of a complementary good *shift* the demand curve for the other good. Changes in a good's own price cause a *move along* the same demand curve. The effects of price changes in substitute and complementary goods on demand are summarized in Figure 5.15.

complement
A good that is purchased and used in combination with another good.

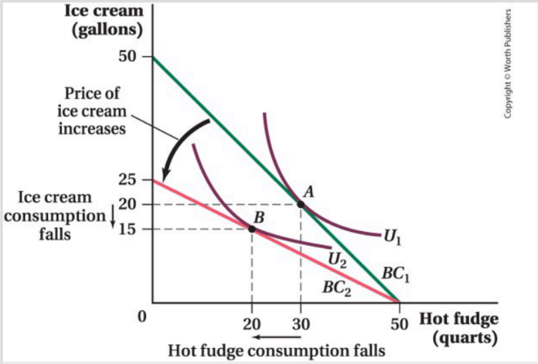

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Figure 5.14 When the Price of a Complement Rises, Demand Falls

At the original prices, the consumer consumes 20 gallons of ice cream and 30 quarts of hot fudge at the utility-maximizing bundle *A*. When the price of ice cream increases, the consumer's budget constraint rotates inward from

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to

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At the new optimal consumption bundle *B*, the consumer decreases their consumption of ice cream from 20 to 15 gallons and likewise decreases their consumption of hot fudge from 30 to 20 quarts. An increase in the price of ice cream causes the consumer to demand not only less ice cream (this is the own-price effect we've studied so far in this chapter), but also less hot fudge, the complementary good.

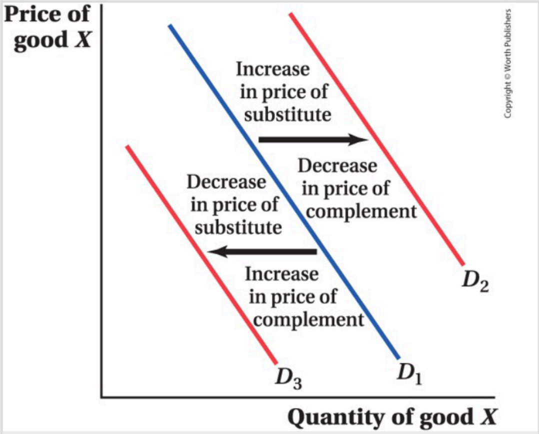

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Figure 5.15 Changes in the Prices of Substitutes or Complements Shift the Demand Curve

When the price of a substitute good rises or the price of a complement falls, the demand curve for good *X* shifts outward. When the price of a substitute good falls or the price of a complement rises, the demand curve for good *X* shifts inward.

Indifference Curve Shapes, Revisited

As we touched on before, the shape of indifference curves is related to whether two goods are substitutes or complements. The more curved the indifference curve, the less substitutable (or, equivalently, the more complementary) are the goods.

In Section 5.3, we learned that the size of the substitution effect from a change in a good's *own* price was larger for goods with less-curved indifference curves (see Figure 5.9). The logic behind this is that, because the marginal rate of substitution (MRS) doesn't change much along straighter indifference curves, a given relative price change will cause the consumer to move a longer distance along their indifference curve to equate their MRS to the new price ratio. This logic holds true when it comes to the effects of changes in *other* goods' prices. All that matters to the substitution effect are the *relative* prices; whether it's the price of good *A* or the price of good *B* that changes doesn't matter. Therefore, an increase in a good's price will create a larger movement toward a substitute good when the indifference curves between the goods are less curved. (A decrease in a good's price will create a larger movement away from the substitute good.)

make the grade

Simple rules to remember about income and substitution effects

It is easy to get tripped up when you're asked to identify income and substitution effects. To avoid confusion, always start your analysis on the indifference curve associated with the consumption bundle *before* the price change. If you want to know why consumption changed going from one bundle to the other, you must start with the initial bundle.

Next, keep in mind the key distinctions between the two effects listed in the table below.

Substitution Effects	**Income Effects**
Involve comparisons of bundles that lie on the same indifference curve.	Involve comparisons of bundles that lie on two different indifference curves.
The direction of the effect on quantity consumed for a given change in the relative price of the good is unambiguous.	The direction of the effect on quantity consumed for a given change in the relative price of the good is ambiguous and depends on whether the good is normal or inferior.
If the good's relative price falls, the substitution effect causes the consumer to want more of it.	If the good is normal, then a fall in either its price or the price of the other good will cause the consumer to want more of it. (A drop in any price, even of another good, increases the effective income of the consumer.) If the good is inferior, then a price drop will cause the consumer to want less of it.
If the good's relative price rises, the substitution effect causes the consumer to want less of it.	If the good is normal, then a rise in either its price or the price of the other good will cause the consumer to want less of it. If the good is inferior, then a rise in either price will cause the consumer to want more of it.

Finally, remember that the total effect of a price change (for either good) on quantity consumed depends on the relative size of the substitution and income effects. If the price of one good falls, the quantities of both goods consumed may rise, or consumption of one good may rise and consumption of the other good may decline. But the quantities consumed of both goods cannot both decline, because this would mean the consumer would not be on her budget constraint.

Application: What the Pandemic Taught Us about Movies

Improvements in home electronics like large-screen, high-definition TVs, streaming video, and compact surround sound audio systems have greatly reduced the price of having a high-quality movie-watching experience at home. A middle-class family today can buy a home theater system that a multimillionaire could have only dreamed about a few decades ago.

The influence lower priced, home-viewed movies have on the number of movies people watch in a theater depends on whether the two are substitutes or complements. If home electronics replicate the theater experience, if people only want to see a movie once, and if people enjoy the convenience of watching at home, then theatrical releases and streaming releases would be substitutes. On the other hand, what if watching more films at home makes people become more interested in films in general—if, for example, they become invested in certain franchises or find themselves watching films multiple times? In that case, they might become more likely to go see a movie in a theater than they would have beforehand, particularly if theaters offer some component of the movie-watching experience that they can't get at home (audiences to laugh or scream along with, early film releases, a huge screen, greasy popcorn, etc.).

The Covid-19 pandemic offered a stark test of the substitutes-versus-complements question. The pandemic effectively raised the price of watching a movie at a theater, whether due to government restrictions on indoor gatherings or people's own skittishness about being in a crowded theater. If theater-viewed movies and home-viewed movies are substitutes, the higher price for one good (movies in a theater) should increase demand for its substitute (movies at home). On the other hand, if they are complements, then the higher price of movies in a theater should decrease the demand for movies at home.

The data are clear on this question. Total U.S. box office sales fell from
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in 2019 to
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in 2020 and
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on 2021. A little of that drop reflected cuts in ticket prices as desperate theater companies tried to entice moviegoers back, but most was a drop in the number of tickets sold. On the other hand, subscriptions to streaming services that offer movies at home accelerated. For example, Netflix subscribers grew by
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(implying they added another 20 million or so U.S. subscribers) between 2019 and 2021. Disney+, which launched at the end of 2019, grew to 40 million U.S. subscribers by the end of 2021. Amazon Prime Video and other streaming services also extended their reach into movie watchers' homes. Home streaming has become so ubiquitous that movie studios now regularly release films simultaneously to home streaming and theaters, effectively acknowledging that for at least a good share of potential movie watchers, the home-viewing experience is a good substitute for going to a cinema.

Maybe this substitutability between entertainment at movie theaters and at home isn't so surprising. In 1946, before TVs were in most people's homes, the average American went to 28 movies a year! A decade later, when TVs had been installed in about
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of American homes, in-theater attendance per person was half that. ■

5.5 Combining Individual Demand Curves to Obtain the Market Demand Curve

When studying consumer demand, we're often more interested in the combined demand of all consumers, rather than just one consumer's demand. If a government wants to figure out how much revenue a tax on soda will raise, for example, it needs to look at the entire market demand for soda.

The market demand for a good is the sum of all the individual demand curves. That is, the market quantity demanded for a good at a particular price is the sum of every individual consumer's quantity demanded at that price. Figure 5.16 shows graphically how this adding up works. Suppose first that you and your cousin Ethan are the only two consumers in the market for sets of wireless speakers (a and b). The total market demand curve (c) is obtained by summing *horizontally* each of the individual demand curves. Adding up the individual consumers' quantities demanded at all possible prices gives the market demand curve.

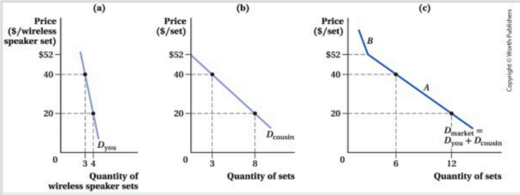

Figure 5.16 Market Demand Curve

(a) Your individual demand curve
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shows the number of sets of wireless speakers you would demand at each price. At a price of
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per set, you demand 3 sets; at
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per set, you demand 4 sets.

(b) Your cousin Ethan's individual demand curve
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shows that he is more sensitive to price changes in speakers than you are. At a price of Error parsing MathML: error on line 1 at column 679: Opening and ending tag mismatch: img line 0 and annotation-xml per set, he similarly demands 3 sets, but when the price of a set of speakers is Error parsing MathML: error on line 1 at column 679: Opening and ending tag mismatch: img line 0 and annotation-xml, he demands 8 sets.

(c) In a market consisting only of you and your cousin, the total market demand curve Error parsing MathML: error on line 1 at column 859: Opening and ending tag mismatch: img line 0 and annotation-xml is the sum of your demand curve Error parsing MathML: error on line 1 at column 850: Opening and ending tag mismatch: img line 0 and annotation-xml and your cousin's demand curve Error parsing MathML: error on line 1 at column 859: Opening and ending tag mismatch: img line 0 and annotation-xml. At a price of Error parsing MathML: error on line 1 at column 679: Opening and ending tag mismatch: img line 0 and annotation-xml per set of speakers, you and your cousin each demand 3 sets, summing to 6 sets on Error parsing MathML: error on line 1 at column 859: Opening and ending tag mismatch: img line 0 and annotation-xml. When speaker sets cost Error parsing MathML: error on line 1 at column 679: Opening and ending tag mismatch: img line 0 and annotation-xml each, you demand 4 sets and your cousin demands 8, summing to 12 sets of speakers on Error parsing MathML: error on line 1 at column 859: Opening and ending tag mismatch: img line 0 and annotation-xml. At prices above Error parsing MathML: error on line 1 at column 679: Opening and ending tag mismatch: img line 0 and annotation-xml, your cousin's quantity demanded is zero, so Error parsing MathML: error on line 1 at column 859: Opening and ending tag mismatch: img line 0 and annotation-xml overlaps with Error parsing MathML: error on line 1 at column 850: Opening and ending tag mismatch: img line 0 and annotation-xml, and therefore Error parsing MathML: error on line 1 at column 859: Opening and ending tag mismatch: img line 0 and annotation-xml is kinked at a price of Error parsing MathML: error on line 1 at column 679: Opening and ending tag mismatch: img line 0 and annotation-xml. Market demand will always be flatter and will never be to the left of the individual demand curves.

The Market Demand Curve

There are a few things to notice about market demand curves. First, a market demand curve will never be to the left of any individual demand curve, because all consumers combined must consume at least as much of a good at a given price as any single consumer does. For a similar reason, the slope of the market demand curve must also be as flat as, or flatter than, any of the individual demand curves. That is, for a given change in price, the change in quantity demanded for the market as a whole must be at least as great as the change in quantity demanded by any individual consumer.[6] Finally, if the price is so high that only one consumer wants any of the good, the individual demand curve for that consumer will lie directly on top of the market demand curve at that price. At this point, the consumer *is* the market.

Using Algebra to Move from Individual to Market Demand

We can move from individual to market demand algebraically as well as graphically. The formulas for the two demand curves in Figure 5.16 are

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To find the market demand for the speakers, we start by adding up the two individual demand curves—adding the *Q*s at a given *P*:

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If we plug in the prices from Figure 5.16, they match the quantities in the figure as long as we are on the part of the curve labeled *A*, where quantities demanded by both you and your cousin are above zero. According to the equation, market demand when Error parsing MathML: error on line 1 at column 864: Opening and ending tag mismatch: img line 0 and an is Error parsing MathML: error on line 1 at column 997: Opening and ending tag mismatch: img line 0 and an which is what the figure shows, and when Error parsing MathML: error on line 1 at column 864: Opening and ending tag mismatch: img line 0 and an Error parsing MathML: error on line 1 at column 1000: Opening and ending tag mismatch: img line 0 and a just as on the figure.

We're not quite done yet, though. The prices at which you and your cousin will consume no speakers—the demand choke prices—are different. Yours is Error parsing MathML: error on line 1 at column 678: Opening and ending tag mismatch: img line 0 and an your cousin's is

Error parsing MathML: error on line 1 at column 675: Opening and ending tag mismatch: img line 0 and an
(You can check this by plugging these prices into the demand curves and verifying that the quantities demanded equal zero.) That means at prices above
Error parsing MathML: error on line 1 at column 675: Opening and ending tag mismatch: img line 0 and an
the market demand is only *your* demand because your cousin's quantity demanded is zero. There is no negative quantity demanded allowed. This isn't accounted for when we add together the two demand curves above, however, because at prices above
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the part of the market demand curve coming from the formula for
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is less than zero. Therefore, market demand is your demand,
Error parsing MathML: error on line 1 at column 941: Opening and ending tag mismatch: img line 0 and an
for prices between
Error parsing MathML: error on line 1 at column 675: Opening and ending tag mismatch: img line 0 and an
and
Error parsing MathML: error on line 1 at column 678: Opening and ending tag mismatch: img line 0 and an
(quantity demanded is zero at prices higher than
Error parsing MathML: error on line 1 at column 678: Opening and ending tag mismatch: img line 0 and an
and is
Error parsing MathML: error on line 1 at column 941: Opening and ending tag mismatch: img line 0 and an
(yours plus your cousin's) for prices below
Error parsing MathML: error on line 1 at column 675: Opening and ending tag mismatch: img line 0 and an
That is, the market demand has a kink at
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make the grade

Adding demand curves horizontally, not vertically

Moving from individual demand curves to market demand is conceptually fairly simple. There's just one thing you have to be careful about. Market demand curves are derived by adding *quantities* of individual demand curves, not prices. That is, individual demands are graphically added horizontally, not vertically.

When you add horizontally, you are summing up all the individual quantities demanded, holding price fixed. This is exactly what you want to do because market demand is the total quantity demanded at any given price. If you add individual demand curves vertically, however, you are holding quantities demanded fixed while adding up the prices. That's a very different conceptual exercise and one that, in this case at least, doesn't really make any sense.

Likewise, if you are combining individual demand curves algebraically rather than graphically, make sure you've written out the individual demand curves as quantities demanded as a function of price. When you add those equations, you'll just be adding the quantities, which is again what you want to do. If you instead try to add equations where prices are a function of quantities (economists call these "inverse demand curves"), again you'll be doing the very different exercise of adding up prices across individuals while holding the quantities fixed.

figure it out 5.4

Suppose that at a rural gas station in Toby Acres, there are only two customers, Johnny (who drives a gas-powered pickup truck) and Olivia (who drives a compact hybrid). Johnny's demand for gasoline is
Error parsing MathML: error on line 1 at column 1090: Opening and ending tag mismatch: img line 0 and annotation-xml,
while Olivia's demand is
Error parsing MathML: error on line 1 at column 1090: Opening and ending tag mismatch: img line 0 and annotation-xml,
where *Q* is measured in gallons and *P* is the price per gallon.

a. Solve for the market demand equation for gasoline at Toby Acres.
b. Draw a diagram showing the market demand curve for gasoline at Toby Acres.

Solution:

a. The market demand curve is the horizontal sum of the buyers' demand curves. Remember that summing horizontally means adding up quantities demanded at each price. This means that we can get the market demand by adding
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and
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But there is more to the story than solving for the summation of the two demand curves. Johnny is not willing to buy any gas if the price is greater than or equal to
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per gallon because that is his demand choke price:

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So, once the price hits
Error parsing MathML: error on line 1 at column 688: Opening and ending tag mismatch: img line 0 and annotation-xml,
only Olivia will be in the market. Her demand choke price is
Error parsing MathML: error on line 1 at column 688: Opening and ending tag mismatch: img line 0 and annotation-xml:

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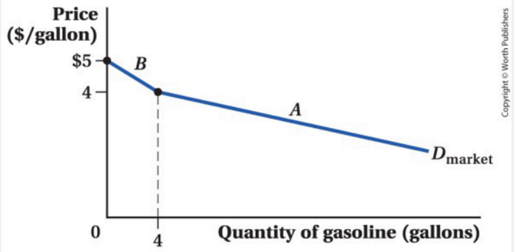
Thus, as long as the price is below Error parsing MathML: error on line 1 at column 688: Opening and ending tag mismatch: img line 0 and annotation-xml per gallon, the market demand for gasoline is the horizontal sum of the two buyers' demand curves. Between a price of Error parsing MathML: error on line 1 at column 688: Opening and ending tag mismatch: img line 0 and annotation-xml and Error parsing MathML: error on line 1 at column 688: Opening and ending tag mismatch: img line 0 and annotation-xml, the market demand is simply the same as Olivia's demand. At a price greater than or equal to Error parsing MathML: error on line 1 at column 688: Opening and ending tag mismatch: img line 0 and annotation-xml, quantity demanded is zero.

b. The figure here shows the market demand for gasoline in Toby Acres. Notice that the market demand curve is kinked as a result of the buyers' different choke prices. Segment *A* is the section of demand below the price of Error parsing MathML: error on line 1 at column 684: Opening and ending tag mismatch: img line 0 and annotation-xml and is the horizontal summation of Johnny's and Olivia's demand for gasoline. Segment *B* is the segment of market demand where Olivia is the only buyer (since the price is above Johnny's demand choke price). At a price of Error parsing MathML: error on line 1 at column 684: Opening and ending tag mismatch: img line 0 and annotation-xml or above, quantity demanded is zero.



5.6 Conclusion

In this chapter, we used the consumer choice model from Chapter 4 to see where demand curves come from and what factors shift them. We studied how changes in various factors that drive consumer demand for a good—the consumer's income, the good's price, and the prices of other goods—affect the consumer's utility-maximizing bundle and, through this, the demand curve.

We broke down the response of a consumer's choices to a price change in a good into two components: the substitution effect and the income effect. The substitution effect reflects changes in quantities consumed due to the new relative prices of goods after the price change. The income effect reflects the fact that a price change affects a consumer's buying power, and this, in turn, changes the consumer's optimal consumption bundle.

We also saw how individuals' demand curves for a good are added up to create the market demand curve for that good.

This chapter ends our examination of the factors that determine consumer demand. In the next chapter, we move on to producer behavior and the supply side of markets.

Summary

1. Shifts in income holding prices constant are reflected in parallel shifts in the budget constraint and affect a consumer's demand curve. An **income expansion path** connects a consumer's optimal bundles at each income level, and an **Engel curve** shows the relationship between income and the quantity of a good demanded. Whether an increase in income raises or reduces the quantity demanded of a good depends on the type of good. **Normal goods** are those for which demand increases with income. **Inferior goods** are those for which demand decreases with income. Within normal goods, goods with an **income elasticity** between zero and 1 (those whose share of expenditure rises more slowly than income rises) are called **necessity goods.** Goods with an income elasticity greater than 1 (those whose share of expenditure grows faster than income) are called **luxury goods.** [Section 5.1]
2. The way in which changes in the price of a good affect the quantity demanded of that good is what creates the shape of the demand curve. We construct a consumer's demand curve by examining what happens to a consumer's utility-maximizing bundle as the price of one good changes, holding the price of the other good, income, and preferences fixed. Changes in income, holding preferences and prices constant, can shift the demand curve. Changes in preferences, holding income and prices constant, can shift the demand curve. **[Section 5.2]**
3. The **total effect** on the quantity demanded of a good in response to a change in its own price can be broken down into two components.

   The **substitution effect** causes the consumer to shift toward the good that becomes relatively cheaper and away from the good that becomes relatively more expensive. This shows up as a movement along the consumer's initial indifference curve, driven by the change in relative prices.

   The **income effect** occurs because a change in the price of a good changes the purchasing power of the consumer; a price drop increases purchasing power and expands the set of bundles a consumer may choose from, while a rise in price decreases purchasing power and reduces the consumer's options. The income effect shows up as a move to a new indifference curve, reflecting a change in utility for the consumer. The direction of the income effect on quantity demanded depends on whether the good is normal (where demand rises when income rises) or inferior (demand falls when income rises). If the income effect is large enough for inferior goods, it is theoretically possible for the quantity demanded of a good to rise when its price rises. However, these types of goods, called **Giffen goods,** are exceedingly rare in the real world. **[Section 5.3]**
4. Changes in the prices of other goods shift the demand curve for a good. Which way these cross-price effects shift demand depends on the nature of the relationship between the goods. Goods are **substitutes** if a price increase in one leads to an increase in demand for the other, due to consumers switching away from the now more expensive good and toward the substitute. Goods are **complements** if an increase in one's price causes demand for the other to fall. Complements are goods that are often consumed together. **[Section 5.4]**
5. Individuals' demand curves are aggregated to get total market demand. Market demand at a given price is the sum of all individual demands at that same price. Another way of saying this is that market demand is the horizontal (i.e., quantity) sum of individual demands. **[Section 5.5]**

Review Questions

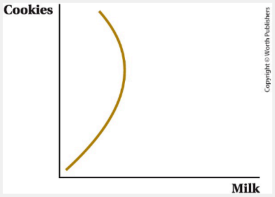
1. Define the income effect. What variables do we hold constant in order to isolate the income effect?
2. What are the differences between normal goods, inferior goods, and luxury goods?
3. Both the income expansion path and the Engel curve show the effect of income on consumption choices. When might you choose to use the income expansion path? When might the Engel curve be more useful?
4. Describe how we can derive a consumer's demand curve from his indifference curves. Why would we expect the demand curve to slope downward?
5. Name at least three factors that can shift an individual's demand curve for pizza. Also describe the effect each factor has on demand (e.g., does it rise or fall?).
6. Define the substitution effect. How does it relate to the income effect?
7. Describe how to decompose the consumer's response to price changes into the substitution and income effects.
8. How do income and substitution effects differ between normal and inferior goods?
9. What is a Giffen good?
10. What are complements and substitutes?
11. If demand for one good increases when the price of another good falls, are the two goods complements or substitutes? What if the demand for one good decreases when the price of the other falls?
12. What can the shape of the indifference curve tell us about two goods?
13. How does the market demand relate to individual demand curves?
14. Why will a market demand curve always be at least as flat as a given individual demand curve?

Problems

1. Show, using indifference curves and budget constraints, that
   a. all goods can be normal, but
   b. all goods cannot be inferior.
2. Joelle consumes food and clothing. For incomes near her current income, her income expansion path is negatively sloped. Indicate whether each of the following statements is true or false, and provide a brief explanation why. (You may want to use a graph in formulating your explanation.)
   a. At current income levels, food must be an inferior good.
   b. At current income levels, clothing must be an inferior good.
   c. At current income levels, food and clothing must be inferior goods.
   d. At current income levels, either food or clothing must be an inferior good.
3. Suppose that, holding prices constant, Alice has preferences over the number of books she purchases that look like:

Income (thousands of dollars)	Optimal number of books purchased
5	5
10	6
15	20
20	25
25	26
30	10
35	9
40	8
45	7
50	6

   a. Draw a smooth approximation of Alice's Engel curve for books, indicating the ranges over which books are inferior goods and over which they are normal goods.
   b. A luxury good is a good that has an income elasticity greater than 1. Give the ranges in which books are luxury goods for Alice.
4. Suppose that Grover consumes two goods, cookies and milk. Grover's income expansion path is shown in the diagram below. Use the information in the diagram to explain whether each of the statements below is true or false. Provide an explanation for each answer.



   a. At low levels of income, both cookies and milk are normal goods for Grover.
   b. As Grover's income grows, eventually cookies become an inferior good.
   c. Draw, intuitively, the Engel curve for Grover's consumption of milk at various incomes.
   d. Draw, intuitively, the Engel curve for Grover's consumption of cookies at various incomes.

5. College sophomore Martin enjoys attending sporting events and going to concerts. Because his scholarship pays for room and board, he spends all his income on these live events. Every once in a while, a doting aunt sends a cash gift to Martin; of course, he spends this additional sum on attending more sporting events and concerts.

   a. True or false: Both sporting events and concerts are luxury goods for Martin. (*Hint:* Use the income elasticity of demand to determine the answer to this question.)

   b. True or false: If concerts are a luxury good to Martin, sporting events must be an inferior good. Explain your answer, referring to the formula for the income elasticity of demand.

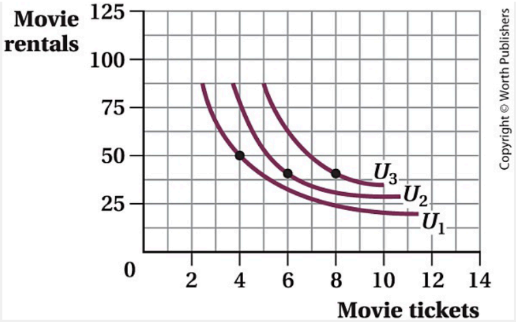
6. Chloe makes Error parsing MathML: error on line 1 at column 682: Opening and ending tag mismatch: img line per week and spends all her income on books and tea. Books cost Error parsing MathML: error on line 1 at column 679: Opening and ending tag mismatch: img line each, and Chloe buys 16 each week. Tea costs Error parsing MathML: error on line 1 at column 676: Opening and ending tag mismatch: img line per cup, and Chloe buys 20 cups. When Chloe's income falls to Error parsing MathML: error on line 1 at column 682: Opening and ending tag mismatch: img line per week, she cuts her consumption of books by 3 books and purchases 5 more cups of tea. Based on these figures, indicate whether each of the following statements is true or false, and briefly explain your reasoning.

   a. Books are an inferior good.

   b. Tea is a necessity.

   c. Books are a luxury good and tea is an inferior good.

7. Consider the following graph, which illustrates Tyler's preferences for movie rentals and in-theater movie tickets:



Suppose that movie rentals always cost Error parsing MathML: error on line 1 at column 676: Opening and ending tag mismatch: img line and Tyler's income is Error parsing MathML: error on line 1 at column 682: Opening and ending tag mismatch: img line per week.

   a. If the price of a movie ticket is Error parsing MathML: error on line 1 at column 687: Opening and ending tag mismatch: img li draw Tyler's budget line. Be very careful to draw to scale. How many movies does he see in the theater?

   b. Begin to draw Tyler's demand curve for movie tickets by creating a new set of axes with price on the vertical axis and the quantity of movie tickets on the horizontal axis. Plot a point that shows how many movie tickets Tyler demands when the price of movie tickets is Error parsing MathML: error on line 1 at column 687: Opening and ending tag mismatch: img li

   c. The movie theater changes the price of tickets to Error parsing MathML: error on line 1 at column 696: Opening and ending tag mismatch: img li Modify the graph provided to reflect this price change. Then add a point to

your demand curve graph to show how many movie tickets Tyler demands at a price of
Error parsing MathML: error on line 1 at column 696: Opening and ending tag mismatch: img li

d. Tyler's school offers a discount card that allows him to purchase movie tickets for
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each. Modify the graph provided to reflect this price change. Then add a point to your demand curve graph to show how many movie tickets Tyler demands at a price of
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e. Connect the dots in the graph you created to complete Tyler's demand curve for movie tickets.

8. Juliette spends
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each month on Oreo cookies (which cost
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per package) and salt and vinegar chips (which cost
Error parsing MathML: error on line 1 at column 676: Opening and ending tag mismatch: img line
per bag).

a. With chips on the horizontal axis, draw Juliette's budget constraint, making sure to indicate the horizontal and vertical intercepts.

b. Suppose that at current prices, Juliette purchases 6 bags of chips each month. Draw an indifference curve tangent to Juliette's budget constraint consistent with this choice (assume Juliette is maximizing her utility). Label her chosen bundle with the letter *A*. How many packages of Oreos does Juliette buy?

c. Suppose that the price of chips falls to
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per bag, and Juliette increases her chip consumption to 8 bags each month. Draw Juliette's new budget constraint and indicate her chosen bundle with an appropriately drawn indifference curve. Label her utility-maximizing bundle with the letter *B*. (Be sure to determine the right quantities of both chips *and* Oreos!)

d. A major snack food producer has experienced a fire, and the disruption of supply has caused the price of salt and vinegar chips to increase to
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As a result, Juliette cuts her consumption of chips to 5 bags per month. Draw Juliette's new budget constraint and indicate her chosen bundle with an appropriately drawn indifference curve. Label her utility-maximizing bundle with the letter *C*. (Again, be sure to determine the right quantities of both chips *and* Oreos!)

e. Draw a new diagram below your indifference curve diagram. Use your answers to parts (b)–(d) to draw Juliette's demand for chips. Indicate her quantities demanded at prices of
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Error parsing MathML: error on line 1 at column 684: Opening and ending tag mismatch: img li
Error parsing MathML: error on line 1 at column 684: Opening and ending tag mismatch: img li
Is there an inverse relationship between price and quantity demanded?

9. Armen lives in Washington State, where grapes are grown. Armen's twin Allen lives in New York, where grapes must be trucked in from Washington at a fixed cost of
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per pound of grapes. Armen and Allen have identical tastes, but Armen tends to purchase lower-quality grapes and Allen tends to purchase higher-quality grapes. Use indifference curve analysis to explain this oddity.

10. Klaus cares only about how much he can write. Because a pen will write 7 miles of text and a pencil will write 35 miles of text, Klaus considers them perfect 5 to 1 substitutes. If the price of pens is given by
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and the price of pencils is given by
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and if Klaus's income is given by Y, use indifference curve analysis to derive the demand curve for pencils.

11. Consider the following three graphs, which illustrate the preferences of three consumers (Bob, Carol, and Ted) regarding two goods, apples and peaches. Each consumer has an income of

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and each consumer pays

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for apples and

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for peaches.

   a. Suppose that the price of peaches falls to

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   Draw a new budget line for each consumer and find the new optimal bundle of apples and peaches each would buy. How does the new quantity of peaches compare to the original quantity? Indicate the change in the first column of the table that follows (an increase of 1 unit might be denoted as a

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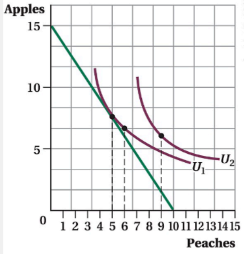
   b. For each consumer, determine the substitution effect of the price change by drawing a hypothetical budget line with the same slope as your new budget line, but just tangent to the consumer's original indifference curve. How much of a change in peach consumption does the substitution effect account for? Indicate that change in the second column of the same table.

(a) Bob



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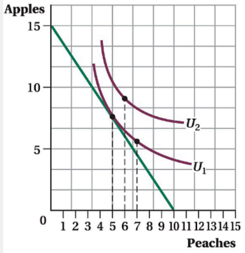
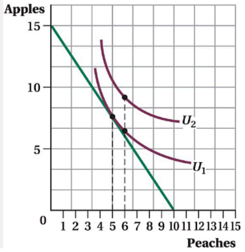
(b) Carol



(c) Ted



c. Now add in the income effect. Compare each consumer's peach consumption in (b) to their final peach consumption in (a). Indicate the difference in column 3 of the table below. Double-check your work to ensure that the last two columns add up to the number in the first column.

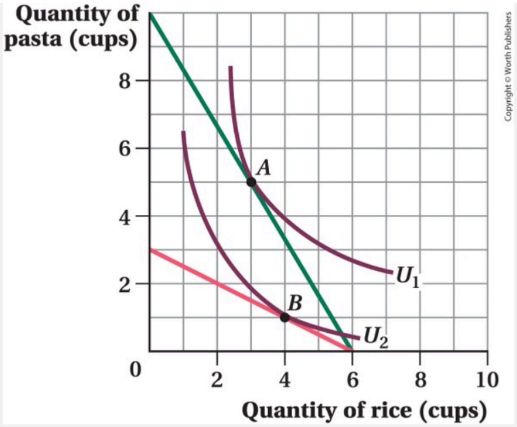
d. Do Bob, Carol, and Ted consider peaches normal, inferior, or income inelastic?

	Total Effect of Price Change	**Substitution Effect of Price Change**	**Income Effect of Price Change**
Bob			
Carol			
Ted			

12. Suppose that Sonya faces an increase in the price of pasta, as depicted below, moving her from an optimal bundle of rice and pasta at *A* to an optimal bundle at *B*.

a. Trace a copy of this diagram. Graphically depict the substitution and income effect.

b. Which effect is strongest? How can you tell?



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13. Brady, who has ordinary-shaped indifference curves, buys 16 ounces of salt each year. Even when the price of salt doubles, Brady continues to purchase exactly 16 ounces.

a. Use indifference curves and budget constraints to depict Brady's behavior graphically. Put salt on the horizontal axis and a composite good on the vertical axis.

b. True or False (and explain): Salt is neither inferior nor normal to Brady.

c. What is Brady's price elasticity of demand for salt?

d. What can we say about Brady's income elasticity of demand for salt?

e. What can we say about the substitution and income effects of a change in the price of salt?

14. Explain intuitively why any normal good cannot possibly be a Giffen good. (You may wish to illustrate your answer with a budget line/indifference curve graph.)

15. Yoshi is a New Yorker who drinks 200 44-ounce sodas each year at a price of
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each. Concerned about burgeoning obesity, the mayor of New York proposes a
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tax on such drinks. The mayor then proposes compensating consumers for the price increase by mailing each resident a check for
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  a. What will happen to Yoshi's consumption of soda? Show the result using an indifference curve diagram with soda on the horizontal axis and a composite good
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  on the vertical axis.

  b. Will Yoshi be better off, worse off, or indifferent to the change? Explain using your diagram.

  c. In terms of revenue, will the government be better off, worse off, or indifferent to the proposal? Explain.

16. Consider the following diagram, which illustrates Gaston's preferences for red beans and rice. Gaston has an income of
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Rice costs
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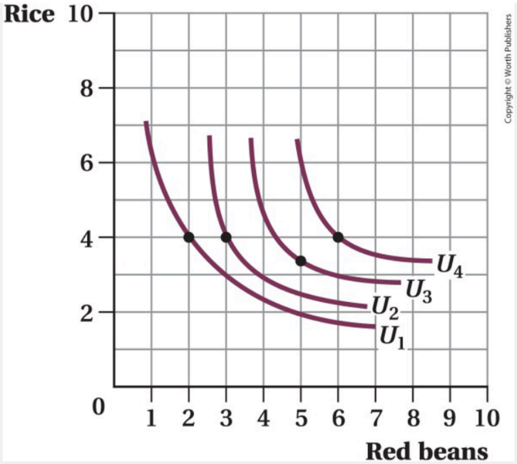
per serving.



  a. Derive Gaston's demand for red beans. Use prices of
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  and
  Error parsing MathML: error on line 1 at column 684: Opening and ending tag mismatch: img li
  in your analysis. Graph your results and connect the points you plotted to yield Gaston's demand for red beans.

  b. Suppose that the price of rice increases to
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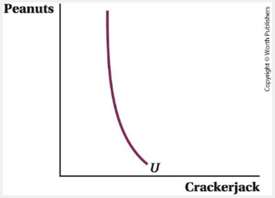
  Again, derive Gaston's demand for red beans using the same prices you used in part (a).

  c. Does Gaston's demand for red beans increase or decrease as a result of the increase in the price of rice?

d. Does your answer to (c) indicate that red beans and rice are substitutes or complements?

17. Consider Liu's indifference curve indicated in the graph below:

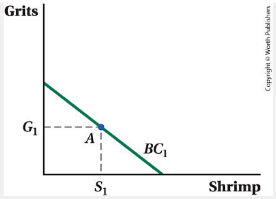


a. True or False (and explain): Peanuts and Crackerjack are clearly complements.

b. True or False (and explain): Peanuts and Crackerjack are clearly both normal goods.

18. True or False: If pizza and calzones are substitutes, then the substitution effect of a price change will be in a different direction than if pizza and calzones are complements. Explain using a diagram.

19. Consider the following diagram, which depicts various combinations of two goods: grits and shrimp. Leon is currently maximizing his utility at point *A* in the diagram.



a. Suddenly, the price of shins decreases by half. Redraw the diagram and show how the change in the price of shrimp alters Leon's budget constraint.

b. Suppose that grits and shrimp are complements. Add an indifference curve to the diagram that shows Leon's new utility-maximizing bundle of grits and shrimp.

c. Redraw part (b), but this time assume that grits and shrimp are substitutes.

20. Reconsider Problem 8, in which you derived Juliette's demand for chips. In that problem, are chips and Oreos complements or substitutes?

21. You may have noticed that the market demand curve is always at least as flat as individual demand curve. Is market price elasticity of demand also always lower than individual price elasticity of demand? Why or why not?

22. Three students have different demands for doughnuts. Andre's demand is given by

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Carlene's demand is given by

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Desmond's demand is given by

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a. Derive the market demand curve for doughnuts algebraically.

b. Graph the market demand curve for doughnuts. Pay special attention to any kinks in the market demand!

Appendix 5A:

The Calculus of Income and Substitution Effects

We saw in this chapter that a price change in one good influences a consumer’s consumption in two ways. The *substitution effect* is the change in a consumer’s optimal consumption bundle due to a change in the relative prices of the goods, holding their utility constant. The *income effect* is the change in a consumer’s optimal consumption bundle due to the change in their purchasing power. In the chapter, we solved for these two effects using a figure like the one below, where good X is shown on the horizontal axis and good Y on the vertical axis. The consumer’s original consumption bundle is A. Consumption bundle B is the optimal bundle after a decrease in the price of X, holding the price of Y constant. Finally, bundle

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shows what the consumer would buy if the price of X decreased but utility stayed the same as at bundle A (i.e., on indifference curve

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Graphically, the substitution effect is the change from bundle A to bundle

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the income effect is the change from

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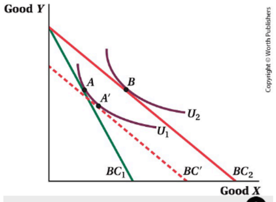
to B, and the total effect is the sum of these two effects or the change from A to B.



The graphical approach to decomposing the income and substitution effects can be a

little messy. You have to keep track of multiple budget constraints, indifference curves, and their respective shifts. The calculus links the effects we observed in the graph to the techniques we learned for solving the consumer's problem in the Chapter 4 Appendix. Solving for these effects is a two-step process. We begin by finding the new consumption bundle *B* to solve for the total effect. Second, we solve for bundle
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which will allow us to identify both the substitution and income effects.

Let's start with a consumer with budget constraint
Error parsing MathML: error on line 1 at column 1153: Opening and ending tag mismatch: img line 0 and a
(Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and a
in the graph) and a standard Cobb–Douglas utility function
Error parsing MathML: error on line 1 at column 1918: Opening and ending tag mismatch: img line 0 and a
where
Error parsing MathML: error on line 1 at column 912: Opening and ending tag mismatch: img line 0 and an
Point *A* in the figure is the solution to the constrained optimization problem:

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In the Chapter 4 Appendix, we derived the solution to this particular utility-maximization problem, and found that the optimal bundle *A* is
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Now suppose that the price of good *X*,
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decreases to
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The consumer has the same utility function as before, but because of the price change, their budget constraint rotates outward to
Error parsing MathML: error on line 1 at column 1295: Opening and ending tag mismatch: img line 0 and a
(Error parsing MathML: error on line 1 at column 748: Opening and ending tag mismatch: img line 0 and a
on the graph). Once again, we rely on utility maximization to solve for the optimal bundle:

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Because we already know the generic solution to this problem, we can plug in the new price of *X* to find the new optimal bundle
Error parsing MathML: error on line 1 at column 3613: Opening and ending tag mismatch: img line 0 and a
This gives us the total effect of the price change on the consumer's consumption bundle—the difference between their new consumption bundle
Error parsing MathML: error on line 1 at column 3082: Opening and ending tag mismatch: img line 0 and a
and their original consumption bundle
Error parsing MathML: error on line 1 at column 3133: Opening and ending tag mismatch: img line 0 and a
Note that in this instance the change in the price of *X* does not affect the quantity of *Y* the consumer purchases. That the demand for each good is independent of changes in the price of the other good is a quirk of the Cobb–Douglas utility function. This result is not necessarily true of other utility functions.

The solution to the utility-maximization problem gives us the final bundle *B*. But we want to know more than just the total effect of the price change on the consumption bundle. We want to decompose this total effect into its two components: the substitution and income effects. We can do this by solving for bundle
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What is the substitution effect? It is the effect of the change in the relative price of two goods on the quantities demanded given the consumer's original level of utility. How can we solve for this effect? It's easy! When we know the consumer's original level of utility and the goods' prices, as we do here, expenditure minimization tells us the answer to the problem. Take the consumer's original level of utility
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as the constraint and set up the consumer's expenditure-minimization problem is

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as a Lagrangian:

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Write out the first-order conditions:

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Solve for *Y* using the first two conditions:

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Plug this expression for *Y* as a function of *X* into the constraint to solve for bundle
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Then plug this optimal value of *X* into the expression for *Y* as a function of *X* from above:

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To simplify, invert the third term and combine like terms:

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Solving the consumer's expenditure-minimization problem at the new prices and original utility level gives us the third piece of the substitution/income effect puzzle: bundle
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[7] Having these three bundles (*A*,
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and *B*) allows us to solve for the substitution and income effects. The substitution effect is the difference between the consumer's original bundle and what that consumer would buy at the new prices but at the old utility level, the difference between *A* and
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The income effect is the difference between what the consumer would buy at the new prices and original utility and what they buy with their new income at the new prices, the difference between
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and *B*. The total effect is the sum of the substitution and income effects or the difference between *A* and *B*.

figure it out 5A.1

A sample problem will make breaking down the total effect of a price change into the substitution and income effects even clearer. Let's return to Figure It Out 4.4, which featured Antonio, a consumer who purchases burgers and fries. Antonio has a utility function
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and income of
Error parsing MathML: error on line 1 at column 649: Opening and ending tag mismatch: img line 0 and annotation-xml.
Initially, the prices of burgers and fries are
Error parsing MathML: error on line 1 at column 646: Opening and ending tag mismatch: img line 0 and annotation-xml
and
Error parsing MathML: error on line 1 at column 646: Opening and ending tag mismatch: img line 0 and annotation-xml,
respectively.

a. What is Antonio's optimal consumption bundle and utility at the original prices?
b. The price of burgers increases to
   Error parsing MathML: error on line 1 at column 649: Opening and ending tag mismatch: img line 0 and annotation-xml
   per burger, and the price of fries stays constant at
   Error parsing MathML: error on line 1 at column 646: Opening and ending tag mismatch: img line 0 and annotation-xml.
   What does Antonio consume at the optimum at these new prices? Decompose this change into the total, substitution, and income effects.

Solution:

a. We solved this question in the Chapter 4 Appendix, but the answer will be crucial to solving for the total, substitution, and income effects in part (b). When a burger costs
   Error parsing MathML: error on line 1 at column 646: Opening and ending tag mismatch: img line 0 and annotation-xml
   and fries costs
   Error parsing MathML: error on line 1 at column 646: Opening and ending tag mismatch: img line 0 and annotation-xml,
   Antonio's original constrained optimization problem is
   Error parsing MathML: error on line 1 at column 2565: Opening and ending tag mismatch: img line 0 and annotation-xml

   We found that Antonio consumes 2 burgers and 5 orders of fries, and his utility for this bundle is
   Error parsing MathML: error on line 1 at column 2058: Opening and ending tag mismatch: img line 0 and annotation-xml.
b. When the price of hamburgers doubles to
   Error parsing MathML: error on line 1 at column 649: Opening and ending tag mismatch: img line 0 and annotation-xml
   each, Antonio faces a new budget constraint:
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Antonio’s new utility-maximization problem is

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Therefore, we should write his constrained optimization problem as a Lagrangian and solve for his new optimal bundle at the higher burger price:

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We use the first two conditions to solve for
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and then solve for *F* as a function of *B*:

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and substitute this value for *F* into the budget constraint:

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In response to the increase in the price of burgers from
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to
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then, Antonio decreases his consumption of burgers and leaves his consumption of fries unchanged. Therefore, the total effect of the price change is that Antonio’s consumption of burgers declines by 1 and his consumption of fries remains the same at 5.

Next, we use expenditure minimization to find the substitution and income effects. Remember that we want to find out how many burgers and fries Antonio will consume if the price of burgers is
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but his utility is the same as his utility when burgers cost
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His third constrained optimization problem is

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We could solve using the Lagrangian as we did above, but instead let’s use what we know about the solution to the consumer’s optimization problem and set the marginal rate of substitution of burgers for fries equal to the ratio of their prices and solve for *F* as a function of *B*:

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Now plug this value for *F* into the consumer’s utility constraint:

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Antonio’s expenditure-minimizing bundle for the new prices and the original utility is

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approximately 1.4 hamburgers and 7 fries compared to his original bundle of 2 hamburgers and 5 fries. As intuition would tell you, the desired consumption of burgers decreases when burgers become relatively more expensive, while the desired consumption of fries increases as fries become relatively less expensive—that’s the substitution effect in action. In particular, Antonio’s substitution effect is to consume 0.6 fewer burgers
Error parsing MathML: error on line 1 at column 1391: Opening and ending tag mismatch: img line 0 and annotation-xml
and 2 more order of fries
Error parsing MathML: error on line 1 at column 1371: Opening and ending tag mismatch: img line 0 and annotation-xml.

While this bundle gives Antonio the same level of utility as the original bundle, he would have to spend about
Error parsing MathML: error on line 1 at column 646: Opening and ending tag mismatch: img line 0 and annotation-xml
more to buy it [his original expenditure was
Error parsing MathML: error on line 1 at column 649: Opening and ending tag mismatch: img line 0 and annotation-xml;
his new one is
Error parsing MathML: error on line 1 at column 1650: Opening and ending tag mismatch: img line 0 and annotation-xml].
Remember, however, that Antonio doesn’t actually purchase this
Error parsing MathML: error on line 1 at column 649: Opening and ending tag mismatch: img line 0 and annotation-xml
combination of burgers and fries. It’s just a step on the way to his final consumption bundle (1 hamburger, 5 orders of fries) that we got from the utility-maximization problem above. We can use this final bundle to find the income effect. Here, the income effect is to consume 0.4 fewer burgers
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and 2 fewer orders of fries
Error parsing MathML: error on line 1 at column 1427: Opening and ending tag mismatch: img line 0 and annotation-xml
because the increase in the price of burgers reduces Antonio’s purchasing power. Notice that the quantity of both goods declines as his purchasing power declines. This means that, for Antonio, they are both normal goods.

In the end, the price change only changes Antonio’s consumption of hamburgers: The total effect on his consumption bundle is 1 fewer burger
Error parsing MathML: error on line 1 at column 1376: Opening and ending tag mismatch: img line 0 and annotation-xml,
which is the sum of the substitution effect
Error parsing MathML: error on line 1 at column 1125: Opening and ending tag mismatch: img line 0 and annotation-xml
and the income effect
Error parsing MathML: error on line 1 at column 1125: Opening and ending tag mismatch: img line 0 and annotation-xml.
On the other hand, the total effect on his consumption of fries is zero because the substitution effect (2 more orders of fries) and the income effect (2 fewer orders of fries) exactly offset one another.

Let’s review what we’ve learned about decomposing the total effect of a price change into the substitution and income effects. To find the original bundle, we solve the utility-maximization problem at the original prices and income. We identify the substitution effect after a price change by solving the expenditure-minimization problem using the new prices with the original level of utility as the constraint. This tells us how a consumer's bundle responds to a price change while leaving the consumer with the same level of utility—the substitution effect. Finally, to find the income effect, we solve the utility-maximization problem using the new prices and the consumer's actual income. Comparing this bundle with the bundle we found using expenditure minimization tells us how consumption responds to the change in purchasing power that is caused by the price change, or the income effect.

Problems

1. Malachi only consumes 2 goods: movie rentals and coffee. His utility function is
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   where *R* is the number of rentals and *C* is cups of coffee. Malachi has
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   in his pocket right now, and he plans to spend all of it on movie rentals and coffee today.

   a. The price of one rental is
   Error parsing MathML: error on line 1 at column 682: Opening and ending tag mismatch: img li
   and the price of coffee is
   Error parsing MathML: error on line 1 at column 682: Opening and ending tag mismatch: img li
   per cup. Solve for Malachi's optimal bundle.

   b. Suppose that Malachi signs up for a membership that reduces the price of a rental to
   Error parsing MathML: error on line 1 at column 682: Opening and ending tag mismatch: img li
   while leaving his income unchanged. Find the substitution effect, the income effect, and the total effect of the decrease in the price of movie rentals on Malachi's consumption of movie rentals and coffee.

   c. From your answer to part (b), are movie rentals and coffee normal or inferior goods for Malachi? Explain.

2. Suppose that a consumer has utility given by
   Error parsing MathML: error on line 1 at column 1497: Opening and ending tag mismatch: img line
   and income of
   Error parsing MathML: error on line 1 at column 680: Opening and ending tag mismatch: img line
   to spend on goods *X* and *Y*.

   a. The prices of *X* and *Y* are both